From:	Jody McCaffree
To:	LNGStudy
Cc:	Moore, Larine
Subject:	2012 LNG Export Study Reply Comments
Date:	Tuesday, February 26, 2013 11:51:28 AM
Attachments:	DOEReply_1_CALNG_Response_Comments_Feb_23_2013.pdf DOEReply_2_ExbA_ExxonMobil_etal_letter_Feb_15_2013.pdf DOEReply_3_ExbB_SWS-report-Feb_2013.pdf DOEReply_4_ExbC_WHO_Endocrine_Disrpt_Study_2012.pdf DOEReply_5_ExbD_Study_Air_Quality_of_Gas_Production.pdf DOEReply_6_ExbE_Colborn_Analysis_Coalbed_Methane.pdf DOEReply_7_ExbF_Renewable_Alternative_Options.doc DOEReply_8_CALNG_petitions.pdf

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Jody McCaffree
Individual / Executive Director
Citizens Against LNG Inc
PO Box 1113
North Bend, OR 97459

February 25, 2013

U.S. Department of Energy (FE-34)
Office of Natural Gas Regulatory Activities
Office of Fossil Energy
P.O. Box 44375
Washington, DC 20026–4375

Re: 2012 LNG Export Study Reply Comments

Dear Ms. Moore:

Please accept the following attached reply comments and exhibits concerning the 2012 NERA LNG Export Study. Please acknowledge receipt of submittal.

Sincerely,

Jody McCaffree

UNITED STATES OF AMERICA
Before the
DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY

In the Matter of:		
NERA Economic Consulting Study	**)**	**FR Doc No: 2012-29894**
"*Macroeconomic Impacts of LNG*	**)**	
***Exports from the United States*"**	**)**	
December 3, 2012	**)**	
	)	

The following Reply Comments sent by Email to LNGStudy@hq.doe.gov

Jody McCaffree
Individual / Executive Director
Citizens Against LNG Inc
PO Box 1113
North Bend, OR 97459

February 25, 2013

U.S. Department of Energy (FE-34)
Office of Natural Gas Regulatory Activities
Office of Fossil Energy
P.O. Box 44375
Washington, DC 20026–4375

Re: 2012 LNG Export Study Reply Comments

Dear Mr. John Anderson / Mr. Edward Myers:

Please accept the following reply comments to issues raised in initial comments submitted to the U.S. Department of Energy (DOE) Office of Fossil Energy (FE) on or before January 24, 2013, concerning the NERA 2012 LNG Export Study.

1. Responding to comments concerning the DOE allowing Unlimited LNG Exports

On January 25, 2013, one day after initial comments were due to the U.S. Department of Energy (DOE) Office of Fossil Energy (FE) concerning the NERA LNG Export Study, Bloomberg reported on an interview that had occurred with Peter Voser, chief executive officer of Royal Dutch Shell Plc on the sidelines of the World Economic Forum's annual meeting in Davos, Switzerland. The interview between Voser and Bloomberg's Ryan Chilcote discussed U.S.

shale-gas production and exports, China's gas reserves and exploration in the Ukraine.[1] A Bloomberg article written about the interview stated the following:

> "Exports will happen," said Voser, 54, whose company is the world's largest LNG supplier. "But I hope that the U.S. will actually keep most of the gas back because it will help them to industrialize parts of the U.S. more." …
>
> …Elsewhere in the world, Shell is optimistic about prospects for shale gas production in China and Ukraine. The company signed a production agreement with the eastern European country yesterday.
>
> "In China, it is very encouraging what we find," Voser said. Shell is exploring for shale gas with China National Petroleum Corp. "If you just look at the reserves it could outnumber the U.S." …[2] (*Emphasis added*)

In response to the concerns raised in initial comments about limiting LNG exports, **if the CEO of Royal Dutch Shell Plc, the world's largest LNG supplier, is saying we should keep back our gas to help us industrialize parts of the U.S., the DOE should seriously take note and consider this in their decision making.** Voser also states in the interview that they are already developing and producing natural gas in China and that Shell is contemplating possibly building their own LNG terminal in North America. Shell is interested in multiple LNG projects including projects to turn gas into liquid fuel such as diesel to power trucks and ships and to feed chemicals plants.

2. Responding to comments about LNG Export Terminals and Options not considered in the NERA Study

The list of proposed LNG export terminals continues to grow and as we previously stated in our initial comments to the DOE, the NERA study did not consider the impacts of all the proposed and/or potential LNG export projects that are in the works in North America. In our January 24, 2013, comments we made a list of proposed, potential and already existing LNG terminals on the West Coast. Since that time additional details about proposed and potential LNG terminals and export options for the West Coast have been brought to our attention:

Alaska

On February 15, 2013, executives from ExxonMobil, BP, ConocoPhillips and TransCanada submitted a letter to Alaska Governor Sean Parnell outlining the concept for an **Alaska LNG project and related pipeline**. The facility would be located on the North Slope near Prudhoe Bay and would receive approximately 3 – 3.5 Bcf/d of natural gas and produce 15 - 18 million

[1] http://www.bloomberg.com/video/shell-may-build-own-u-s-lng-export-terminal-BdUodfh7QpCl5XRLD1eD7g.html

[2] Bloomberg "*U.S. to Cap LNG Exports to Boost Economy, Shell's Voser Says"* By Will Kennedy - Jan 25, 2013 ; http://www.bloomberg.com/news/2013-01-25/u-s-will-cap-lng-shipments-to-boost-economy-shell-s-voser-says.html

tonnes per annum (MTPA) of LNG. This is considerably more than what we had previously listed in our initial comments for this particular LNG proposal. (*See Exhibit A for their letter*)

Canada

Another proposed Canadian LNG Export project not mentioned in our "initial" comments is currently being proposed by Progress Energy Canada Ltd. (Progress), a wholly owned subsidiary of Petroliam Nasional Berhad (Pertronas). Progress Energy is proposing to construct and operate the **Pacific Northwest LNG Project** on Lelu Island within the lands and waters under the jurisdiction of the Prince Rupert Port Authority, within the District of Port Edward, British Columbia (BC). This project would convert natural gas from northeast BC into LNG for export to Pacific Rim markets in Asia. Two LNG carrier berths would accommodate two 217,000 m^3 capacity LNG carriers up to 315 m long. The facility would receive approximately 3 Bcf/d of natural gas and produce up to 18 million tonnes per annum (MTPA) of LNG.[3] On February 19, 2013, the Canadian Environmental Assessment Agency (CEAA) started their environmental review of the project. This is yet another example of a North American LNG export project not considered in the NERA economic study and analysis.

Hawaii

The NERA study also did not consider the economic impacts from alternative LNG export options such as what is being proposed by The Gas Company, LLC, out of Hawaii. Despite the fact that the Jordan Cove Energy Project listed Hawaii as a potential receiver of their LNG exported gas, The Gas Company, LLC, submitted to FERC on August 9th [4] an application [5] to import LNG via a fleet of up to 20 40-foot cryogenic intermodal containers (also known as "ISO" containers). These "ISO" containers would be transported to Hawaii on common carrier cargo vessels utilizing already existing industries and infrastructure. The company anticipates that it will utilize port facilities on the West Coast, such as the ports of Los Angeles and Long Beach, California. The company could potentially also utilize ports on the U.S. Gulf Coast. It would seem that using already existing infrastructure and industries would be far less environmentally impacting and more economical than building additional pipelines and LNG terminals. A properly completed Economic and Environmental Programmatic Analysis would have brought this option to light and is another example as to why it is essential that this type of analysis be completed first before the DOE makes any further decisions with regard to LNG exports.

[3] *Pacific Northwest LNG – Project Description* ; Prepared for Progress Energy Canada Ltd. by Stantec Consulting Ltd.; February 2013; Project No. 1231-10537; http://www.ceaa-acee.gc.ca/050/documents/p80032/86105E.pdf

[4] Application to FERC by The Gas Company, LLC, out of Hawaii for Authorization under Section 3 of the Natural Gas Act; August 9, 2012; http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20120809-5100

[5] ISO is an international organization for standardization which establishes standards for the construction of these containers. ISO-certified intermodal containers are bulk transport units designed to be shipped from one mode of transportation to another (*e.g.*, from truck to ship) or from one location to another.

3. Responding to comments concerning Shale Natural Gas Resources and Impacts

Many initial comments to the DOE including our own expressed concerns with regard to the impacts from hydraulic fracturing of Shale beds and the viability of Shale resources and reserves. The NERA study as we have already stated did not address any of this in its analysis. Several studies have been published since the DOE January 24, 2013, comment deadline which contain information on this issue that should be considered by the DOE.

3.1 ***"Shale and Wall Street – Was the Decline in Natural Gas Prices Orchestrated?"***
By Deborah Rogers, February 2013, Energy Policy Forum: (*See Exhibit B*)

As documented in this report listed above, emerging independent information on shale plays in the U.S. confirms the following:

"· Wall Street promoted the shale gas drilling frenzy, which resulted in prices lower than the cost of production and thereby profited [enormously] from mergers & acquisitions and other transactional fees.

· U.S. shale gas and shale oil reserves have been overestimated by a minimum of 100% and by as much as 400-500% by operators according to actual well production data filed in various states.

· Shale oil wells are following the same steep decline rates and poor recovery efficiency observed in shale gas wells.

· The price of natural gas has been driven down largely due to severe overproduction in meeting financial analysts' targets of production growth for share appreciation coupled and exacerbated by imprudent leverage and thus a concomitant need to produce to meet debt service.

· Due to extreme levels of debt, stated proved undeveloped reserves (PUDs) may not have been in compliance with SEC rules at some shale companies because of the threat of collateral default for those operators.

· Industry is demonstrating reticence to engage in further shale investment, abandoning pipeline projects, IPOs and joint venture projects in spite of public rhetoric proclaiming shales to be a panacea for U.S. energy policy.

· Exportation is being pursued for the differential between the domestic and international prices in an effort to shore up ailing balance sheets invested in shale assets

<u>It is imperative that shale be examined thoroughly and independently to assess the true value of shale assets, particularly since policy on both the state and national level is being</u>

implemented based on production projections that are overtly optimistic (and thereby unrealistic) and wells that are significantly underperforming original projections." (*Emphasis added*)

3.2 ***"Drill Baby Drill - Can Unconventional Fuels Usher in a New ERA of Energy Abundance"*** By J. David Hughes, February 2013, Post Carbon Institute [6]

J. David Hughes, the author of the report noted above, is a geoscientist who has studied the energy resources of Canada for nearly four decades, including 32 years with the Geological Survey of Canada as a scientist and research manager. He developed the National Coal Inventory to determine the availability and environmental constraints associated with Canada's coal resources. The Report spells out the details and concludes the following:

> "The U.S. is a mature exploration and development province for oil and gas. New technologies of large scale, multistage, hydraulic fracturing of horizontal wells have allowed previously inaccessible shale gas and tight oil to reverse the long-standing decline of U.S. oil and gas production. This production growth is important and has provided some breathing room. Nevertheless, the projections by pundits and some government agencies that these technologies can provide endless growth heralding a new era of "energy independence," in which the U.S. will become a substantial net exporter of energy, are entirely unwarranted based on the fundamentals. At the end of the day, fossil fuels are finite and these exuberant forecasts will prove to be extremely difficult or impossible to achieve.
>
> "A new energy dialogue is needed in the U.S. with an understanding of the true potential, limitations, and costs—both financial and environmental—of the various fossil fuel energy panaceas being touted by industry and government proponents. The U.S. cannot drill and frack its way to "energy independence." At best, shale gas, tight oil, tar sands, and other unconventional resources provide a temporary reprieve from having to deal with the real problems: fossil fuels are finite, and production of new fossil fuel resources tends to be increasingly expensive and environmentally damaging. Fossil fuels are the foundation of our modern global economy, but continued reliance on them creates increasing risks for society that transcend our economic, environmental, and geopolitical challenges. The best responses to this conundrum will entail a rethink of our current energy trajectory.
>
> "Unfortunately, the "drill, baby, drill" rhetoric in recent U.S. elections belies any understanding of the real energy problems facing society. The risks of ignoring these energy challenges are immense. Developed nations like the United States consume (on a per capita basis) four times as much energy as China and seventeen times as much as India. Most of the future growth in energy consumption is projected to occur in the

[6] *"Drill Baby Drill - Can Unconventional Fuels Usher in a New ERA of Energy Abundance"* By J. David Hughes, February 2013, Post Carbon Institute - http://shalebubble.org/drill-baby-drill/ [**NOTE**: The file size of this report was over 30 MB which made it too large to send and include as an official exhibit by e-mail.].

developing world. Constraints in energy supply are certain to strain future international relations in unpredictable ways and threaten U.S. and global economic and political stability. The sooner the real problems are recognized by political leaders, the sooner real solutions to our long term energy problem can be implemented." (*Emphasis added*)

3.3 "***State of the Science of Endocrine Disrupting Chemicals 2012 – Summary for Decision-Makers***," A Report by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO), Edited by Ake Bergman, Jerrold J. Heindel, Susan Jobling, Karen A. Kidd, R. Thomas Zoeller Publication date: 19 February 2013, [7] (*See Exhibit C*)

On February 19, 2013, an assessment of the state of the science of endocrine disruptors prepared by a group of experts for the United Nations Environment Programme and the World Health Organization was released. Many synthetic chemicals, untested for their disrupting effects on the hormone system, could have significant health implications according to this "*State of the Science of Endocrine Disrupting Chemicals"* report. The document provides the global status of scientific knowledge on exposure to and effects of endocrine disrupting chemicals (EDCs).

Endocrine disruptors are chemical compounds that interfere with the proper function of endocrine systems in humans and other organisms. Substances grouped together as Endocrine Disruptors, and often called EDCs.

The endocrine system includes glands — such as the thyroid, pituitary, pancreas, testes or ovaries — that secrete natural chemicals to regulate growth, behavior, reproduction, metabolism, etc. EDCs may interfere with the amount of natural hormones (such as estrogen or adrenaline) the body makes, block the way they are made, or mimic a hormone and give a "wrong" chemical signal. Endocrine systems are very similar across vertebrate species. Effects shown in wildlife or experimental animals may also occur in humans if they are exposed to EDCs at a vulnerable time and at concentrations leading to alterations of endocrine regulation. Of special concern are effects on early development of both humans and wildlife, as these effects are often irreversible and may not become evident until later in life. The WHO Press Release for their report states the following:

> "We urgently need more research to obtain a fuller picture of the health and environment impacts of endocrine disruptors," said Dr Maria Neira, WHO's Director for Public Health and Environment. "The latest science shows that communities across the globe are being exposed to EDCs, and their associated risks. WHO will work with partners to establish research priorities to investigate links to EDCs and human health impacts in order to mitigate the risks. We all have a responsibility to protect future generations."[8] (*Emphasis added*)

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[7] "*State of the Science of Endocrine Disrupting Chemicals 2012 – Summary for Decision-Makers*," A Report by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO), Edited by Ake Bergman, Jerrold J. Heindel, Susan Jobling, Karen A. Kidd, R. Thomas Zoeller Publication date: 19 February 2013, Languages: English, ISBN: 978 92 4 150503 1 ; http://www.who.int/ceh/publications/endocrine/en/index.html

[8] *Effects of human exposure to hormone-disrupting chemicals examined in landmark UN report*
News release - 19 February 2013 | GENEVA ;

Human exposure to EDCs occurs via ingestion of food, dust and water, via inhalation of gases and particles in the air and through dermal uptake. Several Research Reports have linked EDC's to natural gas development and impacts from hydraulic fracturing of Shale beds. Selected polycyclic aromatic hydrocarbons (PAHs) were found near Shale development sites at concentrations greater than those at which prenatally exposed children in urban studies had lower developmental and IQ scores. The human and environmental health impacts of the non-methane hydrocarbons (NMHCs), which are ozone precursors, should be examined further given that the natural gas industry is now operating in close proximity to human residences and public lands.

You would think that if the United Nations Environment Programme and the World Health Organization are having significant concerns about these issues that the DOE and/or the FERC would be showing some concerns about them too. Unfortunately as we have already indicated in initial comments, the environmental and health impacts of hydraulic fracturing of Shale beds is not being analyzed or considered by either the DOE or FERC despite research showing a clear link to these compounds and other health impacts from this type of gas production.
(*See Exhibits C, D and E*)

4. Responding to Public Official Comments

In response to comments submitted on January 24, 2013, by Rick Wetherell of North Bend, Oregon, and Roger Craddock of Coos Bay, Oregon, we have attached the following petitions and would like to point out links to petition sheets that have previously been submitted to FERC.[9] Thousands of Citizens in the North Bend and Coos Bay area have signed petitions stating they do believe a LNG terminal in our Port is a well conceived or appropriate industry for our Port and would present an unacceptable risk to the citizens living here. Citizens in the Coos Bay Port District have never been allowed to vote on this issue and are no match to the seemingly endless dollars handed out and promised to local elected officials by the Jordan Cove Energy Project.

I would also like to point out that despite the fact the Jordan Cove Energy Project expressed problems in their comments with the Department of Energy's NERA Study, both Mayor Wetherell and Mr. Craddock praised the Report and its findings. Since the NERA Study itself noted its own shortcomings, we hope that the DOE will seriously take those notations and our comments previously made about them into account before making any decisions concerning proposed LNG Export projects including the Jordan Cove Energy LNG Project.

5. Responding to issues raised about China and Coal Imports

I would like to clarify a statement made in our January 24, 2013, comments to the DOE concerning China and their switch from coal exports to coal imports. Historically China has

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http://www.who.int/mediacentre/news/releases/2013/hormone_disrupting_20130219/en/index.html

[9] Petition Filing 1) http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20070326-0003 (14.4MB)
Petition Filing 2) http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20070906-0013 (4.7MB)
Petition Filing 3) http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20091112-5040 - Exhibit P (6.3MB)

been a net coal exporter but in 2009 the global coal market witnessed a dramatic realignment as China burst onto the scene importing coal from as far away as Colombia and the United States. With 182 million tons (Mt) of coal sourced from overseas suppliers in 2011, China has overtaken Japan as the world's top coal importer. [10] Moreover, as the world's top coal consumer, China's imports are predicted to rise significantly again by 2015.[11] Prior to 2009, China was a net coal exporter. Coal is a cornerstone of the Chinese economy, representing 77 percent of China's primary energy production and fueling almost 80 percent of its electricity. Moreover, China is the world's top coal consumer, accounting for nearly half of global consumption in 2010.[12] Despite the fact that China is home to the world's second largest proven coal reserves after the United States, those reserves are not necessarily being mined. According to a Carnegie Policy Outlook Report, "*Understanding China's Rising Coal Imports*," [13] several factors could be contributing to this and China's sudden entrance into coal import markets including transportation bottlenecks, environmental and safety considerations, economic factors, and concerns about depleting coking coal reserves.

For comments made by those accusing the U.S. of violating its World Trade Organization commitments if it should limit LNG exports, if that was the case, why wouldn't it also apply to China and their not developing and/or exporting their own coal reserves?

7. Responding to initial comments concerning Renewable Energy Options

As Erin Crump and several others have pointed out in their initial comments to the DOE, the real solution to our energy problems is to develop alternative energy developments such as wind, solar, geothermal and other sustainable renewable energy solutions and options. The following attachment on Renewable Energy Alternative Solutions (*See Exhibit F*) clearly shows how this can be and is already being done in some parts of the country. Renewable energy solutions can meet our energy needs not only in the United States but essentially across the entire world. **It would make far more economic sense for us to be exporting renewable energy products and solutions over environmentally impacting and difficult to obtain fossil fuels.** This would also be more in line with the *public interest*. As referenced above from the recent report by J. David Hughes, fossil fuels are finite and the exuberant forecasts of natural gas from shale beds will prove to be extremely difficult or impossible to achieve. The sooner the real problems are recognized by political leaders, the sooner real solutions to our long term energy problem can be implemented.

We stand with Industries and Associations who commented to the DOE such as Alcoa, American Forest & Paper Association, American Iron and Steel Institute, American Public Gas

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[10] O. Tsukimori and C. Aizhu, "*China overtakes Japan as world's top coal importer*," Reuters, January 26, 2012, www.reuters.com/article/2012/01/26/coal-china-japanidUSL4E8CQ3GS20120126 .
[11] R. Kebede and M Taylor, "*China coal imports to double in 2015*," Reuters, May 30, 2011
[12] National Bureau of Statistics, *China Energ y Statistical Yearbook* (Beijing: China Statistics Press, 2012); *Statistical Review of World Energ y* (London: British Petroleum, 2011).
[13] Carnegie Policy Outlook, "*Understanding China's Rising Coal Imports*" Kevin Jianjun Tu and Sabine Johnson-Reiser, February 16, 2012, http://www.carnegieendowment.org/files/china_coal.pdf

Association, CarbonX Energy Corporation Inc, DOW Chemical Company, Industrial Energy Consumers of America, Nucor Corp, Rentech Inc, The Aluminum Association, and The Fertilizer Institute in their concerns with the DOE's NERA LNG Export Study.

We also stand with the concerns and issues raised with the NERA LNG Export Study by citizen and environmental groups who commented such as the Catskill Citizens for Safe Energy, Citizen Power, Clean Line Energy Partners Inc, Clean Ocean Action, Credo Action, Keep Tap Water Safe, Landowners United, New York Climate Action, Pepacton Institute LLC, Save our Supplies (SOS), The Natural Resources Defense Council (NRDC) – Clean Energy Council, Cascadia Wildlands, Environmental Working Group, Civil Society Institute, Food and Water Watch, Oregon Shores, Oregon Wild, Sierra Club, Joseph Patrick Quinn of Umpqua Watersheds, and the Delaware Riverkeeper Network along with 87 other Organizations and thousands of citizens.

We continue to request that the complete Economic and Environmental Impacts of LNG Exports be fully considered in a Programmatic Review and that the National Environmental Policy Act be followed and adhered to first [14] by the U.S. Department of Energy, Office of Fossil Energy before any decisions regarding LNG Exports are made.

Sincerely,

/s/ Jody McCaffree

Jody McCaffree

[14] December 12, 2012, Letter from Citizens Against LNG to Oregon Governor Kitzhaber (sent also to the DOE FE) addressing issues with regard to the Jordan Cove Energy Project and NEPA regulations. http://elibrary.ferc.gov/idmws/file_list.asp?accession_num=20121218-0008

Index Reference for Exhibits

Exhibit A:
February 15, 2013, letter to Alaska Governor Sean Parnell from executives at ExxonMobil, BP, ConocoPhillips and TransCanada outlining the concept for an **Alaska LNG Export project and related pipeline.** http://gov.alaska.gov/parnell_media/resources_files/letter021513.pdf

Exhibit B:
Shale and Wall Street – Was the Decline in Natural Gas Prices Orchestrated?" By Deborah Rogers, February 2013, Energy Policy Forum
http://energypolicyforum.org/portfolio/was-the-decline-in-natural-gas-prices-orchestrated/

Exhibit C:
"***State of the Science of Endocrine Disrupting Chemicals 2012 – Summary for Decision-Makers***," A Report by the United Nations Environment Programme (UNEP) and the World Health Organization (WHO), Edited by Ake Bergman, Jerrold J. Heindel, Susan Jobling, Karen A. Kidd, R. Thomas Zoeller ; Publication date: 19 February 2013
http://apps.who.int/iris/bitstream/10665/78102/1/WHO_HSE_PHE_IHE_2013.1_eng.pdf

Exhibit D:
"***An Exploratory Study of Air Quality near Natural Gas Operations***" - Peer-reviewed and accepted for publication by Human and Ecological Risk Assessment (November 9, 2012). Theo Colborn, Kim Schultz, Lucille Herrick, and Carol Kwiatkowski
http://www.endocrinedisruption.com/files/HERA12-137NGAirQualityManuscriptforwebwithfigures.pdf

Exhibit E:
"An Analysis of Possible Increases in Exposure to Toxic Chemicals in Delta County, Colorado Water Resources as the Result of Gunnison Energy's Proposed Coal Bed Methane Extraction Activity"- October 22, 2002, Letter by Theo Colborn, PhD to the Colorado Bureau of Land Management and the United States Forest Service.
http://www.endocrinedisruption.com/files/cP02591Colborn20021022coalbedmethane2-BEcommments.pdf

Exhibit F:
Renewable Energy Alternative Options – Studies, News Articles and Information **c**ompiled by Jody McCaffree

Petition Exhibit:
Current Citizens Against LNG Petition sheets

ExxonMobil ConocoPhillips bp TransCanada

February 15, 2013

Governor Sean Parnell
550 West 7th Avenue, Suite 1790
Anchorage, Alaska 99501

Dear Governor Parnell,

On October 1, 2012 we updated you on the progress ExxonMobil, ConocoPhillips, BP and TransCanada had made to advance North Slope natural gas development. At that time, we described our plans for progressing concept selection. Today, we are pleased to inform you we have completed the concept selection phase.

Attached is a summary of the major project components, including the gas pipeline, gas treatment facilities and the liquefaction, storage and terminal facilities. The project design also includes five off-take points along the pipeline route to ensure Alaskans access to a cleaner-burning and dependable energy source. Capacity ranges reflect the expected seasonal variability. The conceptual design reflects the integrated teamwork of over 300 people on behalf of our companies.

Our companies are now working toward the next decision points. As outlined in our letter of October 1, 2012, a competitive, predictable and durable oil and gas fiscal environment will be required for a project of this unprecedented scale, complexity and cost, to compete in global energy markets.

A successful Alaska LNG project would result in thousands of jobs and the opportunity for decades of domestically-produced natural gas for homes and businesses in Alaska. We remain committed to responsibly developing the State's considerable resources and will keep you advised of our progress. We also have plans to update the Legislature at a Lunch and Learn on February 19.

Sincerely,

Randy Broiles
ExxonMobil Production Company

Trond-Erik Johansen
ConocoPhillips Alaska, Inc.

Janet Weiss
BP Exploration Alaska

Tony Palmer
TransCanada

Attachment

Proposed Alaska LNG Project Concept

Pipeline	**Diameter**: 42"
	Design Rate[1]: 3 – 3.5 billion cubic feet
	Length: ~800 miles (primarily underground)
	Compressor Stations: up to 8
Gas Treatment Plant	**Location**: North Slope, near Prudhoe Bay
	Footprint: 150 – 250 acres
Liquefaction Plant	**Capacity**[1]: 15 – 18 million tons per annum (MTA)
	Facility: 3 trains
	Footprint: 400 – 600 acres
Storage and Loading	**LNG Storage Tanks**: 2 tanks @ 160,000 cubic meters per tank
	Terminal: 1 loading jetty with 2 berths
State Off-takes	**Off-takes**: 5 points along pipeline route
	Design Rate: 250 – 500 million standard cubic feet per day, based on demand
Capital Investment	**Estimate**[2]: $45 – $65 USD-Billion

[1] Capacity range reflects seasonal variability
[2] Does not include inflation

FEBRUARY 2013

SHALE AND WALL STREET:

WAS THE DECLINE IN NATURAL GAS PRICES ORCHESTRATED?

Deborah Rogers

EnergyPolicyForum

Contents

Executive summary

In 2011, shale mergers and acquisitions (M&A) accounted for $46.5B in deals and became one of the largest profit centers for some Wall Street investment banks. This anomaly bears scrutiny since shale wells were considerably underperforming in dollar terms during this time. Analysts and investment bankers, nevertheless, emerged as some of the most vocal proponents of shale exploitation. By ensuring that production continued at a frenzied pace, in spite of poor well performance (in dollar terms), a glut in the market for natural gas resulted and prices were driven to new lows. In 2011, U.S. demand for natural gas was exceeded by supply by a factor of four.

It is highly unlikely that market-savvy bankers did not recognize that by overproducing natural gas a glut would occur with a concomitant severe price decline. This price decline, however, opened the door for significant transactional deals worth billions of dollars and thereby secured further large fees for the investment banks involved. In fact, shales became one of the largest profit centers within these banks in their energy M&A portfolios since 2010. **The recent natural gas market glut was largely effected through overproduction of natural gas in order to meet financial analyst's production targets and to provide cash flow to support operators' imprudent leverage positions**.

As prices plunged, Wall Street began executing deals to spin assets of troubled shale companies off to larger players in the industry. Such deals deteriorated only months later, resulting in massive write-downs in shale assets. In addition, the banks were instrumental in crafting convoluted financial products such as VPP's (volumetric production payments); and despite of the obvious lack of sophisticated knowledge by many of these investors about the intricacies and risks of shale production, these products were subsequently sold to investors such as pension funds. Further, leases were bundled and flipped on unproved shale fields in much the same way as mortgage-backed securities had been bundled and sold on questionable underlying mortgage assets prior to the economic downturn of 2007.

As documented in this report, emerging independent information on shale plays in the U.S. confirms the following:

- Wall Street promoted the shale gas drilling frenzy, which resulted in prices lower than the cost of production and thereby profited [enormously] from mergers & acquisitions and other transactional fees.

- U.S. shale gas and shale oil reserves have been overestimated by a minimum of 100% and by as much as 400-500% by operators according to actual well production data filed in various states.

- Shale oil wells are following the same steep decline rates and poor recovery efficiency observed in shale gas wells.

- The price of natural gas has been driven down largely due to severe overproduction in meeting financial analysts' targets of production growth for share appreciation coupled and exacerbated by imprudent leverage and thus a concomitant need to produce to meet debt service.

- Due to extreme levels of debt, stated proved undeveloped reserves (PUDs) may not have been in compliance with SEC rules at some shale companies because of the threat of collateral default for those operators.

- Industry is demonstrating reticence to engage in further shale investment, abandoning pipeline projects, IPOs and joint venture projects in spite of public rhetoric proclaiming shales to be a panacea for U.S. energy policy.

- Exportation is being pursued for the differential between the domestic and international prices in an effort to shore up ailing balance sheets invested in shale assets

It is imperative that shale be examined thoroughly and independently to assess the true value of shale assets, particularly since policy on both the state and national level is being implemented based on production projections that are overtly optimistic (and thereby unrealistic) and wells that are significantly underperforming original projections.

Introduction

Unconventional oil and gas from shales has been claimed to be a game changer, revolutionary, "a gift and national treasure". Resource estimates for the U.S. have been giddily referred to as larger than "two Saudi Arabias" by Chesapeake Energy CEO Aubrey McClendon. It has even been said that shale oil and gas will provide energy independence for the U.S.

While such statements are expected from an industry which stands to gain monetarily, a careful, thorough and independent examination of shale production data and company filings demonstrate that shale promises have been vastly overstated, leading to troubling prognostications for the shale industry as a whole and for those regions exploited or planning to be exploited for this resource.

Shale development is not about long-term economic promise for a region. Such economic promise has failed to materialize beyond the first few years of a shale play's life in any region of the U.S. today that has relative shale maturity. Retail sales per capita and median household income in the core counties of the major plays are underperforming their respective state averages in direct opposition to spurious economic models commissioned by industry (see charts in Appendix).

Shale development is not about job creation. Optimistic job estimates by industry have relied heavily on unrealistic multipliers to claim vast numbers of indirect jobs.[1] Such job estimates in industry studies often include professions such as strippers and prostitutes in the overall job gains[2]—not the sort of jobs that most people think of when they hear optimistic numbers from the oil and gas industry. Moreover, direct industry jobs (for onshore and offshore oil and gas) have accounted for less than 1/20 of 1% of the overall U.S. labor market since 2003, according to the Bureau of Labor Statistics.[3] This cannot be construed as game changing job creation.

Shale development is not about the long-term financial viability of shale wells. The wells have not performed up to expectations. Well decline curves are precipitously steep in shale gas and even steeper in shale oil based on historical production data filed by the operators in various states. Typical shale gas wells have an average field decline of 29-52%+ per annum while shale oil fields are declining at about 40%+ per annum.[4] Industry admits that 80% of shale wells "can easily be uneconomic."[5] Massive write-downs have recently occurred which call into question the financial viability of shale assets and possibly even shale companies. In one case, assets were written off for more than 50% of the purchase price within a matter of months.[6]

Further troubling is the realization that shale assets classified as PUDs (proved undeveloped) may not have been properly reclassified by some operators per SEC rules because such reclassification would have resulted in collateral default. The fact that other industry players have been reluctant recently to bid on assets in the Utica shale of Ohio and have abandoned plans for a pipeline for the Bakken shale in North Dakota would seem to suggest a recognition within the industry of the questionable economics and short life span of shales.[7]

Shale development is not about vast reserves or "100 years of gas." A recently published report reviewing production data of over 60,000 shale gas and oil wells observes that

U.S. shale gas has been on a plateau since December 2011, and that 80 percent of shale gas production comes from five plays, several of which are in decline.[8] Further, according to a recent report by the Oil and Gas Journal, and industry publication, it is confirmed that the recovery efficiencies of shale plays are truly dismal. It is stated:

> "The recovery efficiency for the five major [shale gas] plays averages 6.5% and ranges from 4.7% to 10% ...this contrasts significantly with recovery efficiencies of 75-80% for conventional gas fields."[9]

Nor is shale development about technological advancements. Longer laterals have offered little in increased production, even in shale oil. Additional fracture stimulation stages also resulted in very little production gain according to studies conducted by the U.S. Geological Survey.[10]

Due to irresponsibly high debt levels, low cash, and the need to meet production targets for share appreciation, the price of both natural gas and natural gas liquids (NGLs) has been driven to new lows.[11] This complicates the shale picture enormously since margins are now non-existent. Exportation and its concomitant lucrative price spread is clearly seen by industry as offering the best hope for recovering losses.

The new business model of shales

Shale exportation provides a new frontier for shale development in the U.S. Operators are pushing lawmakers to open up vast tracts of land for exploration and development. This would clearly benefit the companies by giving them access at minimal cost and minimal future hassle.

Because of the favorable business climate, including exemption from all major federal environmental statutes and the willingness of some lawmakers to push for exportation, the U.S. has emerged as the preferred location for shale development by large multinational corporations.

It is also interesting to note that in countries such as Poland, once touted as the shale gas savior of Europe, industry has begun to abandon plans to exploit the resource due to higher costs and poor well production.[12] According to Deputy Environment Minister Piotr Wozniak, supplies have so far produced only "humble" results.

Fewer financial and environmental hurdles obviously lead to higher potential for margins and thereby profits. Given the slim margins in shale production at best, it makes good business sense to exploit the U.S. Unfortunately, adequate safeguards are not in place for those communities where such exploitation will take place.

In short, the lower the overall cost to extract shale hydrocarbons, the greater the profit spread particularly when the gas is exported. If export terminals were available today in the U.S., industry could extract, pipe, refine and ship shale gas to Asia for approximately $9/mcf. They would currently get paid as much as $18/mcf. Obviously, this is a highly lucrative spread.

In October of 2011, the Department of Energy granted the first shale gas export permit to Cheniere Energy. At that time, another 7 permits were pending which collectively committed approximately 20% of U.S. shale gas for export. One year later, in November of 2012, the number of permits had grown to 18 and the percentage of shale gas committed for export has grown significantly, accounting for approximately 60% of current U.S. consumption.[13]

It is interesting to note that while once the oil and gas industry exploited other regions of the globe to effect energy security for the U.S., it is now exploiting the U.S. to provide energy security to other regions, primarily Asia. These economies will pay the highest price and thereby offer the most profitability to the individual corporations.

It is, therefore, imperative to take a dispassionate view of this industry. Platform rhetoric about energy independence is nonsense as most within the industry realize. Further, oil and gas companies are not in business to steward the environment, save the family farm or pull depressed areas out of economic decline. If these things should by chance happen, they are merely peripheral to the primary mission of the companies and certainly were never considered in corporate exploration and production plans. Further, given shales' steep declines and thus limited lives, such benefits will be short-lived as well. It would be the height of naïveté to assume that such companies have altruistic intent towards a region or its residents. They do not. Oil and gas companies are in business to extract hydrocarbons as cheaply and efficiently as possible and get them to the customer that will pay the highest price. If they can shave dollars off already thin margins by refusing to use pollution control devices then that is precisely what they will do if it is not mandated, regardless of whether this will increase costs for a region due to pollution or negatively impact other industries. Even though pollution and degradation involve real costs, they are not borne by the industry that perpetrates them in today's economic accounting. This is especially true of the oil and gas industry as they are exempt from federal environmental protection statutes.

If shale developers can export their product to Asia where they will be paid multiples of what they can expect domestically, then that is where the gas will go. Additionally, the oil and gas industry is not in business to provide chemical, plastic and fertilizer manufacturers in the U.S. with low cost feed stock to the obvious detriment of their own bottom lines. Again, this would never be a part of their business model. Nor should it.

The energy context

For the past 100 years fossil fuels have held the primary position as the drivers of the U.S. and western economies. Nevertheless, fossil fuels are finite. New deposits of hydrocarbons have proven harder and harder to replace. Indeed, for more than a decade the largest oil and gas producers (the "Majors" as they are collectively called) have not been able to materially expand their reserve replacement ratios.[14] In fact, approximately one quarter of their reserve growth has come from acquisitions rather than the drill bit, such as ExxonMobil's acquisition of XTO Energy. This constitutes consolidation rather than organic growth.

To give another example, in 2010 Chevron replaced less than one fourth of the oil and gas it had sold the prior year.[15] This is highly problematic for the future share price of these companies and explains the exuberant share repurchase programs which they have engaged in recently, buying back shares in excess of as much $5 billion a quarter in the case of ExxonMobil.[16]

This is, of course, highly problematic for the future health of global economies. It is also problematic for the share prices of the individual fossil fuel companies.

Further, there are various grades and types of hydrocarbons, some much more efficient as fuels than others. Additionally, some hydrocarbons simply require such an expenditure of energy to extract and produce that their use becomes questionable. This measure is referred to EROI (energy returned on investment) and is often seen as a ratio. For instance, it is estimated that in the early days of the U.S. oil industry, the EROI for oil was 100:1 (that is, 100 units of energy recovered for every one unit of energy invested)[17] but this has since declined to an EROI of under 20:1.[18] Because unconventional hydrocarbons like tar sands and shales are by definition more challenging (i.e., more energy-intensive) to produce, they generally have very low EROIs: likely well under 5:1.[19]

Additionally, although industry boldly exclaims each new hydrocarbon discovery with hyperbole, there is a general consensus that we are on the downward slope of hydrocarbon abundance. In April 2011, the chief economist of the International Energy Agency (IEA) Fatih Birol stated: "We think that the crude oil production has already peaked, in 2006."[20]

Street economics: The roots of the crisis

In an environment of declining crude reserves and a now-necessary reliance on low-EROI unconventional hydrocarbons, the oil and gas industry launched a public relations campaign with shale gas and oil of disproportionate scale to the actual performance of the wells. From a business perspective, of course, this made perfect sense.

The financial markets are intricately married to large multinational corporations. Without such markets, companies would be small and local rather than the transnational behemoths of today. Therefore, the growth of companies and the growth of economies relies heavily on the global capital markets.

In order for a publicly traded oil and gas company to grow extensively, it must manage not only its core business but also the relationship it enjoys with its investment bankers. Thus, publicly traded oil and gas companies have essentially two sets of economics. There is what may be called field economics, which addresses the basic day to day operations of the company and what is actually occurring out in the field with regard to well costs, production history, etc.; the other set is Wall Street or "Street" economics. This entails keeping a company attractive to financial analysts and investors so that the share price moves up and access to the capital markets is assured.

"Street" economics has more to do with the frenzy we have seen in shales than does actual well performance in the field.

With the help of Wall Street analysts acting as primary proponents for shale gas and oil, the markets were frothed into a frenzy. Boom cycles have the inherent characteristic of optimism. If left unchecked, such optimism can metamorphose into a mania such as we saw several years ago in the lead up to the mortgage crisis.

The Dallas Federal Reserve Bank noted in their 2011 Annual Report on "too big to fail" financial institutions:

> "Credit default swaps fed the mania for easy money by opening a casino of sorts, where investors placed bets on—and a few financial institutions sold protection on—companies' creditworthiness... Greed led innovative legal minds to push the boundary of financial integrity with off-balance-sheet entities and other accounting expedients. Practices that weren't necessarily illegal were certainly misleading—at least that's the conclusion of many post crisis investigations."[21]

Such similarities can now be seen with shale operators.

In this case, Wall Street once again led the mania by enlisting its army of sell-side analysts to promote shale production. In August of 2011, Neal Anderson of Wood Mackenzie had this to say about the investment community and shale exploration:

> "It seems the equity analyst community has played a key role in helping to fuel the shale gas M&A market, acting as chief cheerleaders for shale gas plays."[22]

A shale company's worthiness was extolled through analyst "buy" recommendations. Investors placed their bets and speculation drove natural gas prices in 2008 to artificially high levels far beyond historical prices. Investors leaped in with reckless and emotional abandon because of the exuberance. The price of natural gas hit a high of $13.50/mcf in 2008, more than twice the historical average of $5-6/mcf. Further, and even more troubling, operators and investors began to refer to such artificially high prices as though they were the new norm. In fact, drilling decisions were made based on an erroneous assumption that prices would never move back to historical levels.

High hopes, no transparency

All overtly exuberant market cycles have one common characteristic: they are overwhelmingly emotional rather than rational in their decision-making processes. This always poses a danger. In hindsight, the mortgage bubble was predicated on years of financial exuberance. A general outlook of "this party can go on forever" had taken hold. New technologies emerged which allowed for much more sophisticated financially engineered products. Creativity abounded on Wall Street. Products were deliberately engineered to reduce the lenders' risk. Or so it was thought.

Banks no longer held on to mortgages. Instead it became lucrative to make loans, package the mortgages, have a ratings agency pronounce it a safe investment and then flip them to investors, thereby collecting large fees. This is not unlike the land grab which shale operators engaged in

by leasing millions of acres of land, drilling a handful of wells and pronouncing the field "proved up" and thereby a "safe" investment, and then flipping such parcels to the highest bidder. This exercise quickly drove prices up.

Before the mortgage crisis, once the extent of the appetite was realized for credit default swaps, representatives of the capital markets worldwide embraced the new products. The fees generated were immense. It was similar with shale. Land was bid up to ridiculous prices with signing bonuses reaching nearly $30,000/acre and leases on unproven fields being flipped for as much as $25,000/acre, multiples of original investment.[23] There seemed an unending appetite.

In another example of parallels: credit default swaps were not traded on any exchange, so transparency became a paramount issue. It proved very difficult to accurately measure the underlying fundamentals with such a lack of transparency. It was the same with shales. Due to the new technology of hydrofracture stimulation, shale results could not be verified for a number of years. There simply was not enough historical production data available to make a reasonable assessment. It wasn't until Q3 of 2009 that enough production history on shale wells in the Barnett had been filed with the Texas Railroad Commission that well performance could be checked.[24] What emerged was significantly different from the operators' original rosy projections. Of further interest is the fact that once numbers could begin to be verified in a play, operators sold assets quickly. This has followed in each play in the U.S. as it matured. The dismal performance numbers were recognized as a potential drag on company share prices. A good example would be the operators in the Barnett play in Texas. The primary players were Chesapeake Energy(significant portion of assets sold or jv'ed), Range Resources (all Barnett assets sold), Encana,(all Barnett assets sold) and Quicksilver Resources (company attempting to monetize all Barnett assets via MLP or asset sale since 2011. In that time frame, stock has plunged from about $15/share to $2.50/ share).

The issue of well performance disclosure has continued to mask problems in shale production. States such as Pennsylvania and Ohio do not release well performance data on a timely basis, which makes it very difficult to get a true picture of actual well history.

Purposeful complexity, willful ignorance

Many highly complex financial products were at the very heart of the mortgage crisis. Interestingly, they have also found a place in shale production.

For instance, in May 2011, Barclays Capital came up with an innovative structure through a volumetric production payment (VPP) which allowed a broader base of investors into a shale deal with Chesapeake Energy. According to Risk, March, 2012:

> "The main challenges in putting together the Chesapeake VPP deal were getting the structure right and guiding the rating agencies and institutional investors—who did not necessarily have deep familiarity with the energy business—through the complexities of natural gas production."[25]

Once again, investors are encouraged into investments in an off-balance sheet transaction which is inherently complex and which they admittedly do not have familiarity with. Further, by Barclay's own admission the ratings agencies needed to be "guided" to fully understand the complexities of the deal.

During the lead up to the mortgage crisis, financial products were actually reverse-engineered to pass the ratings agencies requirements. In addition, lenders sought out clients who were not qualified to assume mortgages.

It is also interesting to note that before the mortgage crisis, Congress encouraged the government agencies of Fannie Mae and Freddie Mac into becoming the largest buyers of mortgage securities, a move that in hindsight was ill-conceived.[26]

Recently some members of Congress have begun advocating the perceived benefits of shale gas and shale oil exportation. It is a controversial position, however, and one which is not necessarily shared by all industry insiders more well-versed in resource potential than Congressional representatives.

In August, 2012, the *New York Times* reported:

> "Last week, more than 40 members of Congress urged President Obama to move forward with approval, citing the benefits of free trade and the prospect of creating more jobs as demand for exports leads to growth in gas production."[27]

And yet, in February, 2012, Lee Raymond, former CEO ExxonMobil stated:

> "Even if you get past the politics, you have to test whether or not the resource base is sufficient [for exportation]…It's going to be a little while before people are really confident that there is going to be a sufficient amount of gas for 30 years…I'm frankly not sure that we have enough experience with shale gas to make the kind of judgment you'd have to make."[28]

In addition, John Hofmeister, the former chief of U.S. operations for Shell, stated in September 2012, "Unless something seriously changes in the next five years, we'll be standing in gas lines because there won't be enough oil to go around."[29]

The drilling treadmill

Mr. Hofmeister said he believes forecasts also understate the "decline" rate of shale fields. The hydrocarbons tend to flow robustly in the first months of drilling, then decline before plateauing at lower levels. Wells have also not been as long-lived as originally forecast.

Mr. Hofmeister concluded that to sustain growth, companies will need to drill many wells at a rate "beyond the capacity of the industry as currently defined…Those who ballyhoo oil shale and say that this will take care of us—no, it won't."

Mr. Hofmeister is referring to a phenomenon known as the "drilling treadmill" or "exploration treadmill." Shale extraction requires continuous and prolific drilling programs covering vast acreage in order to maintain a production plateau. Once drilling begins, it must be maintained or production declines rapidly. In other words, shales are heavily reliant on perpetual expansion. This is highly problematic for a fuel which is to be considered a bridge to alternative energies.

According to Dave Hughes, author of a forthcoming report on U.S. shale plays for the Post Carbon Institute:

> "The sweet spots have now been identified, and [initial productivities] are rising as drilling is focused on these areas. It is only a matter of time, however, until available locations in these areas become saturated and the Marcellus moves into middle age… Due to their high decline rates [tight oil] plays require high levels of capital input for drilling and infrastructure development to maintain production levels."[30]

Hence the drilling treadmill: as production grows, more wells and capital are needed simply to offset the inherent steep declines of shale wells.

Each shale play has essentially followed the same pattern. Operators move into a region and begin a prolific drilling program. Economically, it provides a boost in the short term. The sweet spots are drilled out first as this provides the best possibilities for good wells in addition to good public relations material. In the beginning of a play, individual well productivity appears to climb rapidly. But to extrapolate from this that shale will necessarily provide long term economic stability for a region is highly problematic and unlikely. The older the play, the more difficult it becomes to maintain the production plateau. And the more costly.

Encana's statement from their press release of the sale of all their assets in the Barnett Shale of North Texas illustrates this point quite well:

> "We're going to focus our energies on our higher growth properties that are at earlier stages of development and have more opportunity for growth…The Barnett is not the best place for Encana to put its money.. It's a mature area and the sweet spots have been drilled out."[31]

Each shale play in the U.S. has demonstrated such sweet spots and steep declines. In spite of industry promises of long-term stability, shale plays are known within the industry as statistical plays. Dr. John Lee, the architect of the SEC's rule change for oil and gas and a well-respected petroleum engineer stated:

> "It is sometimes said…that 20% of [shale] wells carry a project; the other 80% can easily be uneconomic."[32]

This adds further problems for shale developers because with so many uneconomic wells it becomes that much harder to keep production flat. Furthermore, all new wells being drilled will follow this 80/20 estimation.

For illustrative purposes, industry would need to drill 561 new wells per year just to offset declines at present using the latest type curve for the Marcellus. Because the Marcellus is a relatively new play, currently there are 1244 new wells being added each year. Thus production is still in the growth phase. As production grows, so does the number of new wells needed to offset declines.[33]

This business model is not sustainable. Once the sweet spots are drilled out, operators begin to sell assets because the costs of trying to maintain a flat production profile are enormous. This corroborates Mr. Hofmeister's statements above.

The cost of maintaining a flat production profile is staggering. For instance, according to Dave Hughes, the cost of a Marcellus well is about $4.5 million, which translates to $2.5 billion each year to offset declines (excluding leasing and infrastructure costs). This is lower than the Haynesville at $7 billion (to maintain a flat production profile) and the Barnett at $5.3 billion.[34]

Financial co-dependency

In the lead up to the financial crisis, Wall Street bundled mortgages of different quality, packaged them and sold them off to investors. Through reverse-engineering to meet the ratings agency's stipulations, they managed to get approximately 80% of these loans classified as investment grade. These were inherently complex financial products. Due to the tremendous appetite for the securities, it then became expedient to originate mortgages. The more mortgages of any quality available, the more that could be packaged and sold to hungry investors. One study found that 68% of all residential mortgages had been originated by a mortgage broker prior to the crisis.[35]

In much the same manner, the shale operators moved into areas and began leasing acreage. Companies vied with one another to bundle vast acreage. Each play followed the same game plan: operators would originate leases and then bundle them.

Aubrey McClendon, CEO of Chesapeake Energy, stated unequivocally in a financial analyst call in 2008:

> "I can assure you that buying leases for x and selling them for 5x or 10x is a lot more profitable than trying to produce gas at $5 or $6 mcf."[36]

This sort of promotion was not peculiar to Chesapeake Energy. In January, 2012, Bloomberg reported:

> "Surging prices for oil and natural gas shales, in at least one case rising 10-fold in five weeks, are raising concern of a bubble as valuations of drilling acreage approach the peak set before the collapse of Lehman Brothers Holdings Inc."[37]

Bundling leases was highly profitable business in much the same manner as bundling mortgages. Operators and sell-side analysts, although not necessarily in admitted collusion, would froth the markets with heady forecasts. Operators would then drill a few wells and declare

the field as "proved up". There was, however, uncertainty as to whether the fields truly were "proved up".

In January, 2012, Bloomberg noted:

> "Chinese, French and Japanese energy explorers committed more than $8 billion in the past two weeks to shale-rock formations from Pennsylvania to Texas after 2011 set records for international average crude prices and U.S. gas demand. As competition among buyers intensifies, overseas investors are paying top dollar for fields where too few wells have been drilled to assess potential production…"[38]

Moreover, production targets added further financial strain to ailing balance sheets.[39] They also added much more gas to already burgeoning supply capacity. This in turn drove prices lower still. In January, 2012, prices plunged under $3/mcf. Break even costs for shale wells were averaging about $4-6/mcf, so operators were facing significant shortfalls.[40]

And yet, the banks who were generating large fees off shale company transactions were still rating these same companies as "buys" to the average investor.

To give an example, Chesapeake Energy announced the sale of assets and a notes offering last February. Bank of America/Merrill Lynch, Morgan Stanley, Deutsche Bank, Goldman Sachs, Jeffries and Royal Bank of Scotland were the banks involved in the deals.

In the days and weeks leading up to the announcements, these same banks issued recommendations on Chesapeake Energy.[41] They were as follows:

Bank of America/Merrill Lynch	Buy
Jeffries and Co.	Buy
Morgan Stanley	Overweight
Goldman Sachs	Hold
Deutsche Bank	Neutral
Royal Bank of Scotland	N/A

At the same time of this announcement, other analysts at institutions which did not stand to gain fees from these transactions had an opposite view of the prospects for Chesapeake Energy.

On February 15, 2012, an analyst in *Deal Pipeline* stated, "Chesapeake is in serious trouble…Its Enron style of media hype, off-balance sheet accounting and excessive leverage has finally caught up with them. The end appears to be close." [42]

Zacks Equity Research placed Chesapeake Energy on bankruptcy watch with an Altman Z score of .84. Anything below 1.80 is considered to be at high risk for bankruptcy.[43]

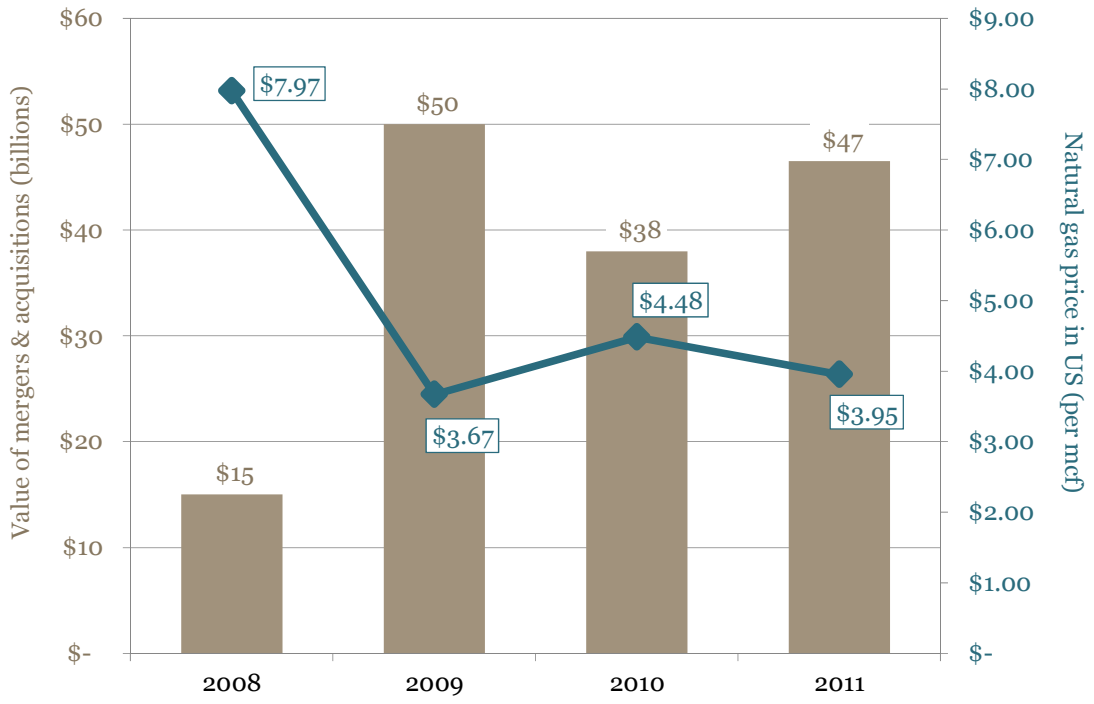
Over the next two months, numerous problems came to light regarding Chesapeake. Reuters broke a story disclosing $1.1B in undisclosed notes.[44] Then it was uncovered that Chesapeake CEO Aubrey McClendon was running a $200 million hedge fund from Chesapeake corporate offices in Oklahoma City trading in the very commodities which Chesapeake produced.[45] Both the Department of Justice and the SEC opened investigations.[46] In Q2-3 2012, the company wrote off over $2B in shale assets and have been forced to sell over $10B in assets just to stay afloat with more asset sales pending and expected.[47] The share price plunged over 40% in a matter of weeks.

Ralph Eads of Jefferies, one of Chesapeake Energy's primary investment banks, was quoted in the *New York Times*, October, 2012, admitting to talking up prices and perhaps even alluding to hoodwinking the Majors who bought shale assets:

> "Typically we represent sellers, so I want to persuade buyers that gas prices are going to be as high as possible…the buyers are big boys—they are giant companies with thousands of economists who know way more than I know. Caveat emptor."[48]

According to KPMG, shale gas accounted for $46.5 billion in deals in the U.S. alone in 2011.[49] The mergers and acquisitions market for shale assets exploded in the prior two years directly in sync with the downward descent of natural gas prices (see chart, below). In much the same way as mortgage backed securities bolstered the banks' profits before the downturn, energy M&A had now become the new profit center within these banks.

Value of Mergers & Acquisitions Compared to Natural Gas Prices, 2008-2011



Data: IHS Herold; Energy Information Administration.

The demise of the NGL market

As the drilling treadmill became more apparent, operators attempted to divert attention away from the plummeting natural gas price by focusing intently on liquids-rich production, announcing concentration on wet gas areas of shale plays. This was an obvious ploy to salvage the appearance of profitability and continue to meet the production targets so necessary for share price appreciation. In effect, however, this focus wreaked havoc on the natural gas liquids (NGL) market in the same way it had eroded natural gas prices.

Analysts did, in fact, recognize the possibility of a glut in NGLs. This would, of course, have placed additional psychological and financial pressure on operators to consider selling assets or seeking joint venture partners, even mergers, which the banks could then effect. About the NGL market, Bank of America/Merrill Lynch stated:

> "Perhaps more importantly, we also find that the weak fundamentals in the NGL market hold some interesting repercussions for natural gas. Although returns on NGL production are currently protecting natural gas producers from low natural gas prices, eventually the glut in the NGL market could catch up with them. Lower NGL prices could then quickly translate into a slowdown in liquid drilling programs if margins contract or turn negative even. In other words, while drilling for NGLs is currently producing a chunk of natural gas at zero cost, the surpluses in the NGL market could come to haunt producers."[50]

That is precisely what happened. In an obvious effort to appease their bankers and shareholders, operators had overproduced yet again and driven prices of NGL's to new lows.

In May, 2012 Reuters reported:

> "U.S. natural gas drillers, stung by decade-low gas prices, have flooded into so-called liquids-rich plays, but the surge in natural gas liquids (NGLs) output that was meant to salvage profitability is leading to a new glut."[51]

By July, 2012 Reuters reported:

> "U.S. oil and gas companies that have depended on natural gas liquids to lift profits may now have to rein in spending or sell some assets after the industry drilled its way into a glut of natural gas liquids."[52]

And the sale of assets began.

An interesting example of NGL overproduction is Range Resources, who heavily touted their emphasis on liquids-rich production. In their earnings call Q4 2011, it was stated:

> "The first is the super-rich Marcellus…Given the high price of oil versus the current low price of gas, this super-rich play enhances the value of our Marcellus economics."[53]

Range management went on to say:

> "The higher volumes are not only the result of drilling in the higher BTU area, but are also the result of drilling longer laterals and completing them with more frac stages. We've also experimented with reduced cluster spacing, decreasing the frac interval from 300 feet to 150 to 200 feet; all of this looks very promising. Once we extract ethane beginning late next year, this will further enhance the economics."[54]

Note that the additional BTUs gained from liquids "are also the result of drilling longer laterals and completing them with more frac stages." This translates into higher costs to extract liquids for which the market was already becoming glutted. Improving the economics in this way has proven to be wishful thinking as Range announced disappointing margins for the last five quarters with a loss of $53.8 million in 3Q 2012.[55]

Oil and gas companies with material exposure to NGLs include Range Resources, Quicksilver Resources Inc., Forest Oil Corp and Pioneer Natural Resources.

Foreign entities buy up U.S. shale

Beginning in 2009, the number of M&A deals within the shale market began to explode. Initially, many transactions involved foreign investors such as Chinese, Korean, French and Norwegian companies looking to purchase U.S. shale assets. The banks effected these transactions for large fees.

CNOOC, a Chinese oil and gas company, paid $1.1 billion for 33.3% of Chesapeake Energy's Eagle Ford acreage and agreed to fund another $1.1 billion of the drilling costs. It is estimated that Chesapeake cleared approximately $10,237 per acre, a significant multiple of original cost.[56] Anadarko, too, has entered into a joint venture with the Korea National Oil Corporation, which agreed to pay $1.55 billion for a 33% share of Anadarko Petroleum's acreage in the Maverick Basin in Texas.[57]

In addition, BHP Billiton, a large Australian mining multinational agreed to acquire Petrohawk Energy Corp, for approximately $15.2 billion paying a considerable premium of approximately 65% to Petrohawk's prior day close.[58] In addition, BHP paid Chesapeake Energy approximately $4.75 billion for its Fayetteville shale assets only to write down in excess of 50% of their value a mere 18 months later.[59] Many other deals were consummated during this time.

By Q2-Q3 2012, shale asset write-downs began in earnest.

Massive write-downs of shale assets

In the lead up to the mortgage crisis, there were hints of things to come in the form of asset write downs. Unfortunately, very few were heeded. In February 2007 HSBS booked a loss on

mortgage assets of $10.5B.[60] In Q3, UBS announced a loss of $690m.[61] In January of 2008, Citigroup announced a loss for the prior quarter of $9.8B.[62] Other write-downs occurred, in addition to Chapter 11 filings for some companies.

Similar hints have been emerging with regard to shale. In May 2012, *Forbes* reported the following:

> "Chesapeake Energy shares closed down 14% today on wording in an SEC filing that the company might have to write down the value of its assets because of record low gas prices and might have trouble meeting its obligations under bond covenants…Although such write-downs don't affect the company's cash balance, they do erode the value of the assets carried on the company's balance sheet. This asset value directly impacts the amount of debt leverage the company can maintain."[63]

In Q3 2012, as predicted, further deterioration occurred for Chesapeake. The company took an additional and considerably larger impairment charge of $2.02B on it shale assets.[64]

Further, in July, 2012, ITG Investment Research, at the request of several large institutional investors, engaged in a study which ultimately questioned Chesapeake Energy's (CHK) claims of booked reserves. ITG gathered its well data from public sources such as production history filed with the Texas Railroad Commission. They concluded that a significant portion of Chesapeake reserves in the Barnett "have no positive value, heralding a potential writedown in our opinion."[65]

Through July and August 2012 the bad news kept pouring in. According to Reuters:

> "Encana said it had recorded a US$1.7 billion non-cash after-tax impairment charge resulting primarily from the decline in 12-month average trailing natural gas prices."[66]

> "Natural gas-focused producer Quicksilver Resources Inc. posted a second-quarter loss on a big impairment charge as weak prices for natural gas and natural gas liquids lower the value of the company's assets…Quicksilver said its results were hurt by a $992 million non-cash impairment of oil and gas properties due to lower prices."[67]

According to the *Financial Times* of London:

> "British Petroleum (BP) said Tuesday it is taking an impairment charge of US$2.11 billion, primarily relating to its U.S. shale gas assets."[68]

> "BHP Billiton (BHP) blamed a glut of gas supply in the US for a US$2.84B impairment charge against the value of its Fayetteville gas assets, which it acquired for US$4.75B 18 months ago."[69]

According to Bloomberg:

> "BG Group, the U.K.'s third-largest oil and gas producer, wrote down $1.3 billion on its U.S. shale fields..."[70]

Further impairments are expected in the coming quarters.

Although companies claim that such charges are not reflective of the fair value of the assets, this is highly questionable given the significant reserve downgrades which the USGS has assigned to all shale plays in the U.S. The fact that some of these companies would have found themselves in collateral default had they accurately reflected their reserves on the books is also extremely troubling.

In view of these significant impairments, deal-making appears to have reached saturation point as of Q3 2012.

According to PriceWaterhouseCoopers, companies with acreage in the Marcellus had enjoyed approximately $32 billion in merger and acquisition deals since the beginning of 2010. The third quarter of 2012, however, was the first in that period with no deals at all. Activity fell to zero.[71]

Given the poor performance of prior shale deals, it appears that investors are becoming more cautious. According to Reuters:

> "...one investment banker said that there is currently 'a little bit of "JV fatigue" ' in the energy industry, noting that some companies might be wary of linking up with the precariously positioned Chesapeake... 'I think that's very true as it relates to Chesapeake, which has a bit of an asterisk beside their name at this point. I think people have found their experience with Chesapeake has been unrewarding...' "[72]

And yet, Chesapeake has been continuously touted by industry and its investment banks to have some of the very best shale acreage in the business.

Companies start pulling out

In spite of all the hype surrounding shale production, it is interesting to note the recent behavior of other industry players with regard to shale assets.

In October, 2011, Norse Energy announced it was putting its 130,000 acres in New York State's portion of the Marcellus up for bid. Over a year later, in December, 2012, Norse Energy had not been able to sell the assets. This, coupled with high levels of debt, forced Norse to declare bankruptcy under Chapter 11.[73]

Although there is a moratorium at present in New York State with regard to hydrofracking, it is generally assumed that fracking will be allowed at some point in the state. The fact that no other

energy company was interested in picking up these assets, however, indicates a distinct lack of confidence in the assets overall.

Other companies have also begun letting their leases expire in New York with no intention to renew. For instance, Anschutz Exploration recently announced that they would not seek to renew leases. According to the *Denver Business Journal* in December 2012:

> "Anschutz Exploration isn't alone. Other companies are letting their oil and gas leases on property in the state lapse because a drilling moratorium, coupled with the threat of tougher regulations, has made New York less attractive for gas operations."[74]

As stated at the beginning of this report, industry relies heavily on fewer business hurdles to effect their drilling programs. Margins are simply too thin in shales and the well performance too poor to justify investment in wells with added regulatory and environmental costs.

It is also interesting to note that in the Utica shale, which Chesapeake Energy CEO Aubrey McClendon boasted in the early days was "the biggest thing to hit Ohio since the plow," operators have experienced difficulties getting joint venture partners for drilling. According to Bloomberg, September 2012:

> "PDC Energy Corp. didn't receive a high enough bid from would-be joint-venture partners for an interest in its Utica holdings and will develop the acreage on its own…"[75]

Information is emerging that the Utica wells are not performing up to expectations. Financial analysts, upon examining the initial well results released by the State of Ohio, characterized them as "underwhelming". According to Reuters:

> "Even Chesapeake has muted its trumpet…In an SEC filing this May, the company said it was planning to drill a significant number of wells in Utica's 'oil window' over the rest of this year, referring to an area that is expected to hold mostly oil. Three months later it said it 'continues to focus on developing the wet gas and dry gas windows,' with no mention of oil. Chesapeake declined to comment on the change in description."[76]

In the Bakken shale of North Dakota, which is primarily an oil shale play, plans to build a pipeline to carry the oil to a large storage facility in Cushing, Oklahoma were recently abandoned. According to Energy and Capital, November 2012:

> "Oneok Inc. (NYSE: OKE) experienced a recent setback after its subsidiary, Oneok Partners LP (NYSE: OKS), failed to secure enough oil producers to justify developing a $1.8 billion Bakken pipeline."[77]

This is of particular interest. Pipeline projects are expensive and require that a steady and consistent stream of gas or oil can be counted on for a long period of time in order to recoup initial capital outlay. Once initial capital is recouped, however, they tend to be cash cows. Given the steep decline curves for shale oil that are now readily apparent, it appears that operators

recognize that the Bakken will not be a long-term play. As such, they are not prepared to invest the needed capital upfront for a pipeline: again, a distinct lack of confidence in the long term viability of shales.

Costs versus benefits

In the 2012 Summary of Revised Regulatory Impact Statement, the New York State Department of Environmental Conservation (DEC) made the following remark regarding high volume hydraulic fracturing (HVHF):

> "The Department considered the denial of permits for HVHF, but while this alternative would fully protect the environment from any environmental impacts associated with HVHF, it would eliminate the economic benefits."[78]

The purported economic benefits of shale gas and oil have been consistently and egregiously overstated by industry in every shale play to date. While there is some initial economic boost, it has proved short-lived and will almost certainly never cover the peripheral costs of production such as long-term environmental degradation, air quality impacts, aquifer depletion and potential contamination, road repairs and health costs just to name a few. The fact that DEC appears unaware of this is troubling and would seem to suggest that DEC has not done proper due diligence.

Examples abound of industry rhetoric which has not lived up to initial promises. For instance, in 2007 Chesapeake Energy, the largest leaseholder in New York State, issued the following statement in a press release regarding their wells at Dallas-Fort Worth Airport (DFW):

> "Assuming an estimated average recovery of approximately 2.5–3.0 billion cubic feet of natural gas equivalent (bcfe) gross reserves per well, the company believes that up to one trillion cubic feet of natural gas equivalent (tcfe) reserves can be produced from under the airport at an all-in finding and development cost of approximately $2.00 per thousand cubic feet of natural gas equivalent (mcfe)."[79]

Firstly, based on actual production history in the Barnett shale, Chesapeake wells average 1.5 Bcf, not 2.5–3.0.[80] Secondly, while Chesapeake claimed that finding and development (F&D) costs were in the range of $2/mcf, independent sources put F&D costs for the Barnett at approximately $4/mcf.[81]

Not only were the wells in significant decline by year-end 2011—a mere four years after the above-mentioned giddy statements of the press release—Chesapeake also found itself settling a lawsuit with DFW Airport with regard to significant underpayment of royalties.[82]

Further, additional peripheral costs are being borne by taxpayers in states where drilling is prevalent. For instance, according to the *Fort Worth Star Telegram*, July, 2012:

> "…the Texas Department of Transportation (TXDOT) told industry representatives and elected officials on Monday that repairing roads damaged by drilling activity would 'conservatively' cost $1 billion for farm-to-market roads and another $1 billion for local roads."[83]

Another article dated 25 December, 2012, from the Associated Press (AP) stated:

> "The first operating loss in about five years at a north-central Pennsylvania hospital is a sign of the influx of natural gas field workers without health insurance, the facility's CEO said…Jersey Shore Hospital president and CEO Carey Plummer told the *Sun-Gazette* of Williamsport that many subcontractors attracted to the area's Marcellus Shale drilling boom do not cover employees."[84]

It is unlikely that such costs will be borne by the oil and gas industry given the poor performance of the wells and industry's frenzy to sell leases and joint venture shale properties. This will continue to prove problematic for states where shale development has occurred.

Moreover such costs must be factored into the overarching economic equations. Shale development is a highly industrial activity with all that entails. The Texas Commission on Environmental Quality submitted a report to U.S. EPA in December 2011, confirming that drilling activities were contributing 42% more volatile organic compounds then all on-road mobile sources in the Dallas-Ft. Worth region, a significant obstacle to ozone attainment goals.[85] Again, a cost to be borne by the taxpayers rather than the industry that created it.

Every region in the U.S. which has shale development provides a cautionary tale. Economic stability has proved elusive. Environmental degradation and peripheral costs, however, have proved very real indeed.

Conclusion

As documented in this report, emerging independent information on shale plays in the U.S. confirms the following:

- Wall Street promoted the shale gas drilling frenzy, which resulted in prices lower than the cost of production and thereby profited [enormously] from mergers & acquisitions and other transactional fees.

- U.S. shale gas and shale oil reserves have been overestimated by a minimum of 100% and by as much as 400-500% by operators according to actual well production data filed in various states.

- Shale oil wells are following the same steep decline rates and poor recovery efficiency observed in shale gas wells.

- The price of natural gas has been driven down largely due to severe overproduction in meeting financial analysts' targets of production growth for share appreciation coupled

and exacerbated by imprudent leverage and thus a concomitant need to produce to meet debt service.

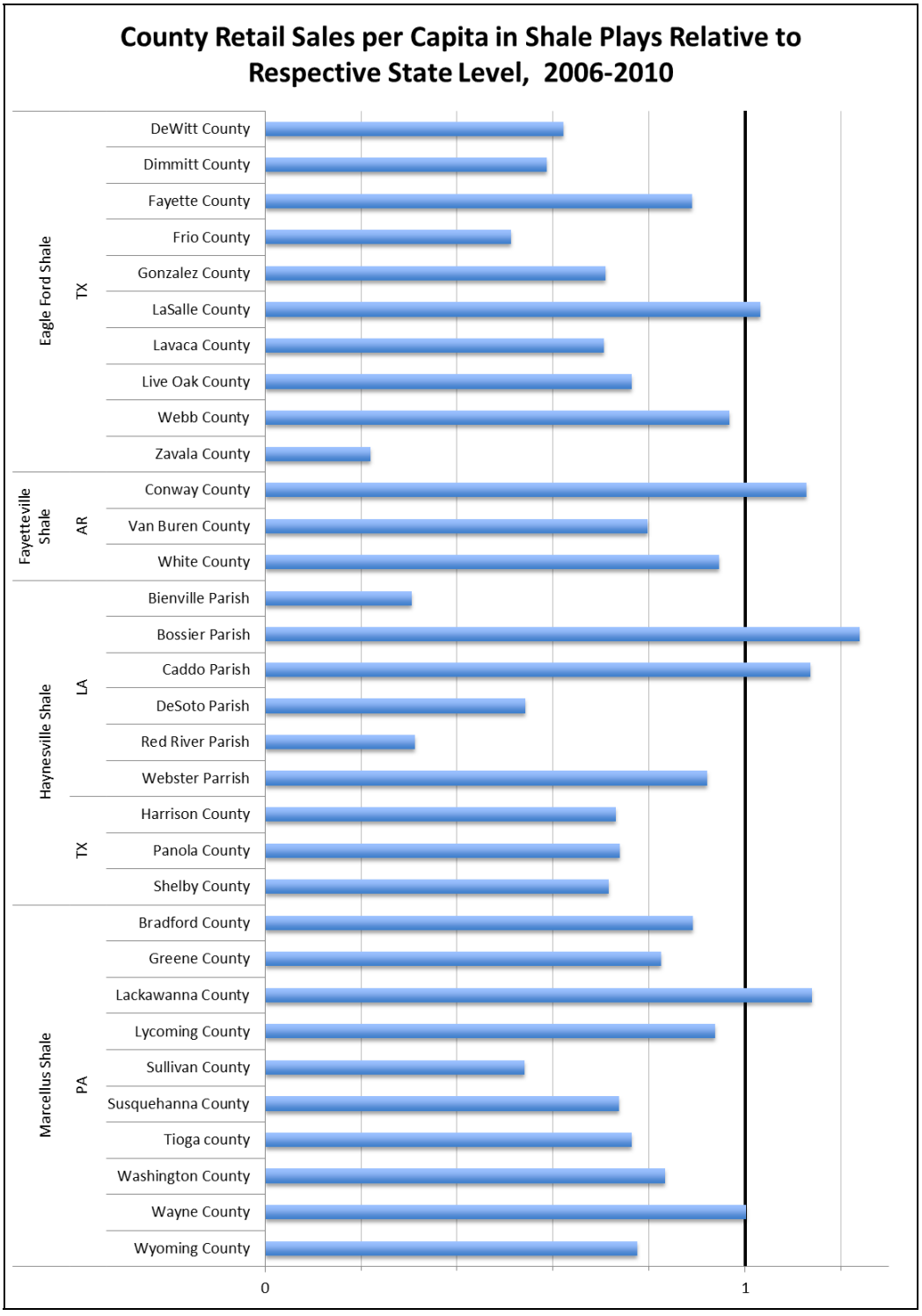
- Due to extreme levels of debt, stated proved undeveloped reserves (PUDs) may not have been in compliance with SEC rules at some shale companies because of the threat of collateral default for those operators.

- Industry is demonstrating reticence to engage in further shale investment, abandoning pipeline projects, IPOs and joint venture projects in spite of public rhetoric proclaiming shales to be a panacea for U.S. energy policy.

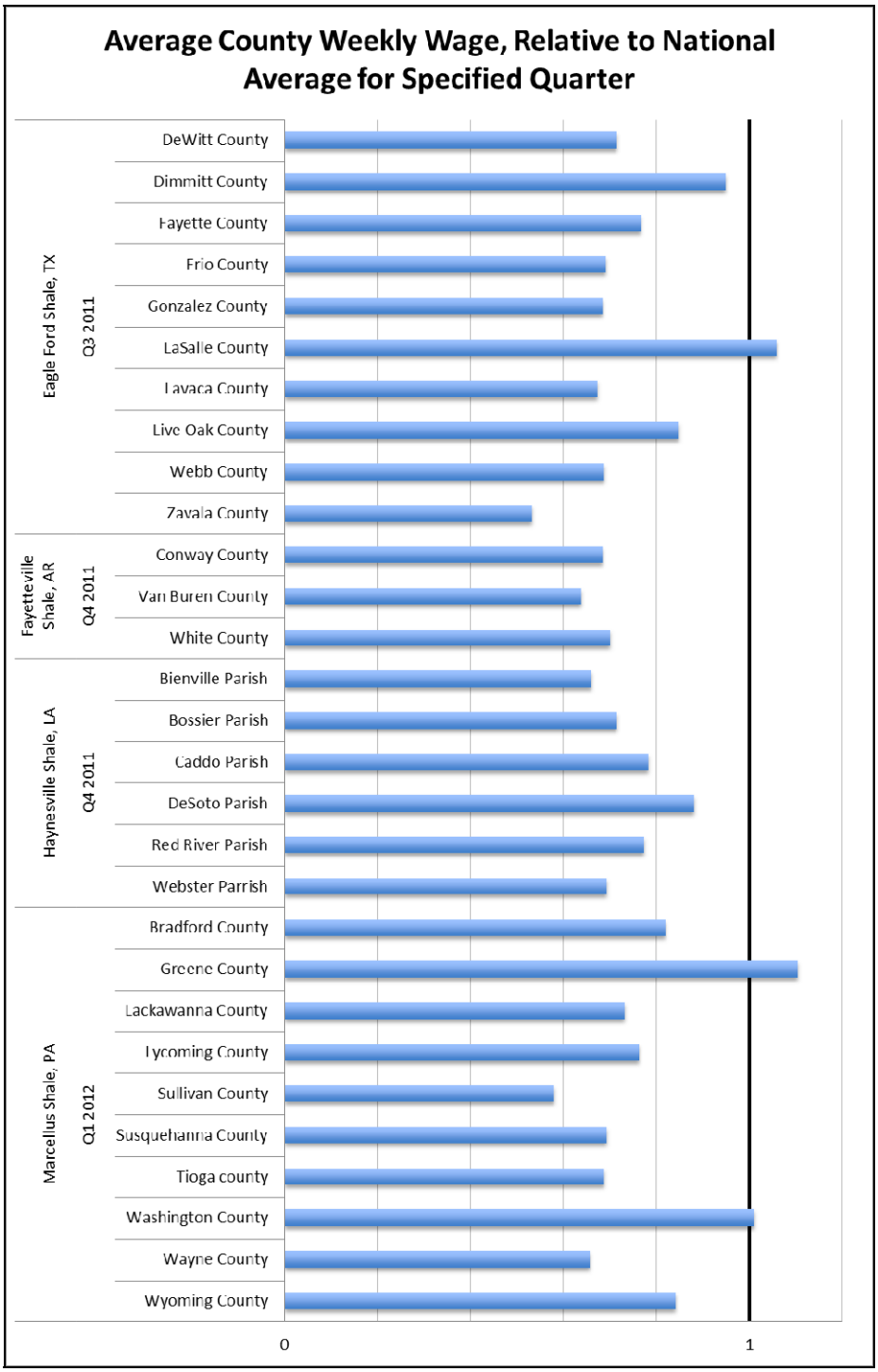
- Exportation is being pursued for the arbitrage between the domestic and international prices in an effort to shore up ailing balance sheets invested in shale assets

It is imperative that shale be examined thoroughly and independently to assess the true value of shale assets, particularly since policy on both the state and national level is being implemented based on production projections that are overtly optimistic (and thereby unrealistic) and wells that are significantly underperforming original projections.

Appendix



Data: U.S. Bureau of Labor Statistics, 2012.



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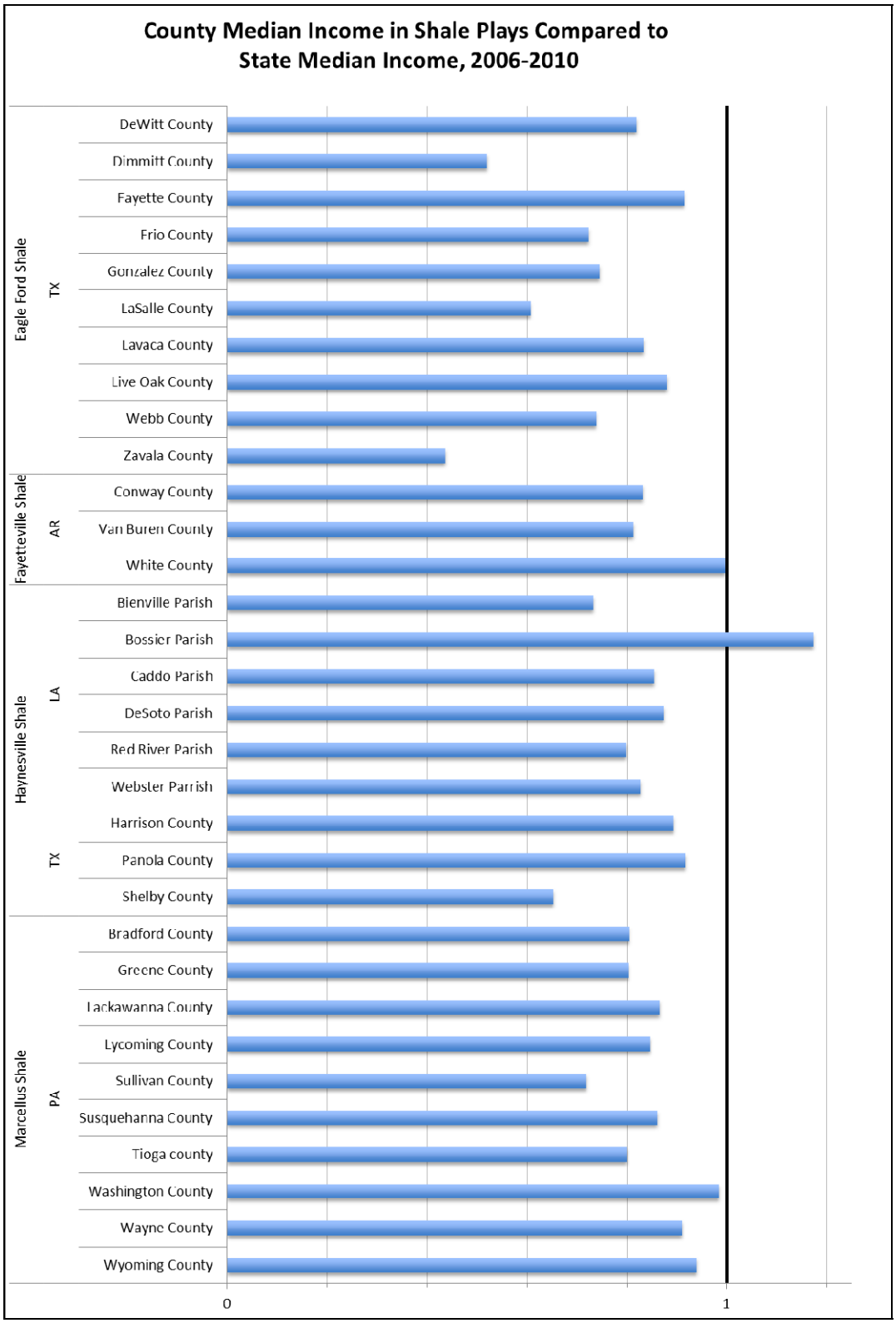

Note: Median household income (MHI), normalized by state.
Data: U.S. Bureau of Labor Statistics, 2012.

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Deborah Rogers began her financial career in London working in investment banking. Upon her return to the U.S., she worked as a financial consultant for several major Wall Street firms, including Merrill Lynch and Smith Barney. Ms. Rogers was appointed as a primary member to the U.S. Extractive Industries Transparency Initiative (USEITI), an advisory committee within the Department of Interior, in 2013 for a three year term. She also served on the Advisory Council for the Federal Reserve Bank of Dallas from 2008-2011. She was appointed in 2011 by the Texas Commission on Environmental Quality (TCEQ) to a task force reviewing placement of air monitors in the Barnett Shale region in light of air quality concerns brought about by the natural gas operations in North Texas. She is a Member of the Board of Earthworks/OGAP (Oil and Gas Accountability Project). She is also the founder of Energy Policy Forum, a consultancy and educational forum dedicated to policy and financial issues regarding shale gas and renewable energy. Ms. Rogers lectures on shale gas economics throughout the U.S. and abroad and has appeared on MSNBC and NPR. She has also been featured in articles discussing the financial anomalies of shale gas in the *New York Times* (June 2011), *Rolling Stone* (March 2012) and the *Village Voice* (September 2012).

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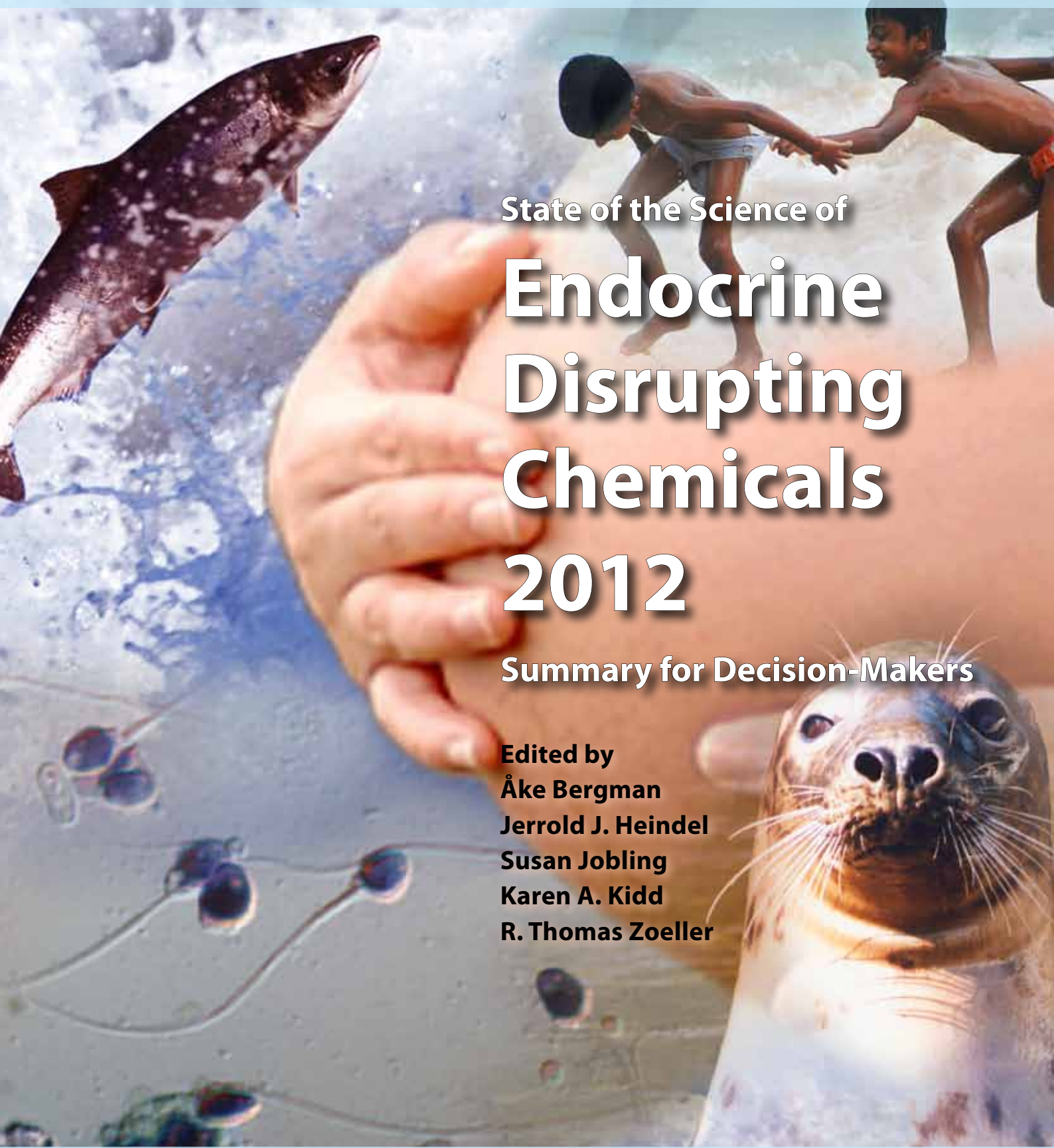

State of the Science of

Endocrine Disrupting Chemicals 2012

Summary for Decision-Makers

Edited by
Åke Bergman
Jerrold J. Heindel
Susan Jobling
Karen A. Kidd
R. Thomas Zoeller

IOMC INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organizations.

The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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State of the Science of

Endocrine Disrupting Chemicals 2012

Summary for Decision-Makers

An assessment of the state
of the science of endocrine disruptors
prepared by a group of experts
for the United Nations Environment Programme
and World Health Organization.

Edited by
Åke Bergman
Jerrold J. Heindel
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World Health Organization

UNEP

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1972-2012:
Serving People
and the Planet

Contents

Preface

This *Summary for Decision-Makers*, together with the main document, *State of the Science of Endocrine Disrupting Chemicals—2012*, presents information and key concerns for policy-makers on endocrine disruptors as part of the ongoing collaboration between the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) to address concerns about the potential adverse health effects of chemicals on humans and wildlife. The main messages from the three chapters of the main document are presented as well.

We live in a world in which man-made chemicals have become a part of everyday life. It is clear that some of these chemical pollutants can affect the endocrine (hormonal) system, and certain of these endocrine disruptors may also interfere with the developmental processes of humans and wildlife species. Following international recommendations in 1997 by the Intergovernmental Forum on Chemical Safety and the Environment Leaders of the Eight regarding the issue of endocrine disrupting chemicals (EDCs), WHO, through the International Programme on Chemical Safety (IPCS), a joint programme of WHO, UNEP and the International Labour Organization, developed in 2002 a report entitled *Global Assessment of the State-of-the-Science of Endocrine Disruptors*.

The Strategic Approach to International Chemicals Management (SAICM) was established by the International Conference on Chemicals Management (ICCM) in February 2006, with the overall objective to achieve the sound management of chemicals throughout their life cycle so that, by 2020, chemicals are used and produced in ways that minimize significant adverse effects on human health and the environment.

SAICM recognizes that risk reduction measures need to be improved to prevent the adverse effects of chemicals on the health of children, pregnant women, fertile populations, the elderly, the poor, workers and other vulnerable groups and susceptible environments. It states that one measure to safeguard the health of women and children is the minimization of chemical exposures before conception and through gestation, infancy, childhood and adolescence.

SAICM also specifies that groups of chemicals that might be prioritized for assessment and related studies, such as for the development and use of safe and effective alternatives, include chemicals that adversely affect, inter alia, the reproductive, endocrine, immune or nervous systems. A resolution to include EDCs as an emerging issue under SAICM was adopted in September 2012 by ICCM at its third session.

EDCs represent a challenge, as their effects depend on both the level and timing of exposure, being especially critical when exposure occurs during development. They have diverse applications, such as pesticides, flame retardants in different products, plastic additives and cosmetics, which may result in residues or contaminants in food and other products. Therefore, EDCs may be released from the products that contain them.

The protection of the most vulnerable populations from environmental threats is a key component of the Millennium Development Goals. As the challenge in meeting the existing goals increases, with work under way in developing countries to overcome traditional environmental threats while dealing with poverty, malnutrition and infectious disease, emerging issues should be prevented from becoming future traditional environmental threats. Endocrine disruption is a challenge that must continue to be addressed in ways that take into account advances in our knowledge.

UNEP and WHO, in collaboration with a working group of international experts, are taking a step forward by developing these documents on endocrine disruptors, including scientific information on their impacts on human and wildlife health and key concerns for decision-makers and others concerned. The well-being of future human and wildlife generations depends on safe environments.

From late 2010 until mid-2012, the working group developed, contributed to and revised sections of the main document during three separate meetings, as well as through teleconferences. Professor Åke Bergman led the working group and facilitated the development of this summary with the editors in coordination with the working group, UNEP and WHO.

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The working group members, scientific experts and contributors of text served as individual scientists and not as representatives of any organization, government or industry. All individuals who participated in the preparation of these documents served in their personal capacity and were required to sign a Declaration of Interest statement informing the Responsible Officer if, at any time, there was a conflict of interest perceived in their work. Such a procedure was followed, and no conflicts of interest were identified.

The development and publication of the two documents were supported by funds provided to UNEP by the Norwegian government, the Swedish Environment Ministry, the Swedish Research Council (FORMAS) and the Swedish Environmental Protection Agency. Further support was provided to WHO by the United States National Institute of Environmental Health Sciences (NIEHS) through cooperative agreement 1 U01 ES02617. The contents of the documents are solely the responsibility of the contributors and do not necessarily represent the official views of the NIEHS.

1. Introduction

This document presents summary information and key concerns for decision-makers on endocrine disrupting chemicals (EDCs) from the full report entitled *State of the Science of Endocrine Disrupting Chemicals—2012*. It is part of the ongoing collaboration between the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) to address concerns about the potential adverse effects of anthropogenic chemicals.

We live in a world in which man-made chemicals have become a part of everyday life. Some of these chemical pollutants can affect the endocrine (hormonal) system and interfere with important developmental processes in humans and wildlife.

Following international recommendations in 1997 by the Intergovernmental Forum on Chemical Safety and the Environment Leaders of the Eight regarding the issue of EDCs, the International Programme on Chemical Safety (IPCS), a joint programme of WHO, UNEP and the International Labour Organization, developed in 2002 a report entitled *Global Assessment of the State-of-the-Science of Endocrine Disruptors* (**Figure 1**) (IPCS, 2002).

The general conclusions from this work were that

> *although it is clear that certain environmental chemicals can interfere with normal hormonal processes, there is weak evidence that human health has been adversely affected by exposure to endocrine-active chemicals. However, there is sufficient evidence to conclude that adverse endocrine-mediated effects have occurred in some wildlife species. Laboratory studies support these conclusions.*

The IPCS (2002) document further concluded that there was a need for broad, collaborative and international research initiatives and presented a list of research needs.

Since 2002, intensive scientific work has improved our understanding of the impacts of EDCs on human and wildlife health. Recent scientific reviews and reports published by the Endocrine Society (Diamanti-Kandarakis et al., 2009), the European Commission (Kortenkamp et al., 2011) and the European Environment Agency (2012) illustrate the scientific interest in and complexity of this issue. These documents concluded that there is emerging evidence for adverse reproductive outcomes (infertility, cancers, malformations) from exposure to EDCs, and there is also mounting evidence for effects of these chemicals on thyroid function, brain function, obesity and metabolism, and insulin and glucose homeostasis.

The Endocrine Society called for timely action to prevent harm (Diamanti-Kandarakis et al., 2009), and the European Society for Paediatric Endocrinology and the Pediatric Endocrine Society, based in the United States of America (USA), put forward a consensus statement calling for action regarding endocrine disruptors and their effects (Skakkebaek et al., 2011).

In 2012, UNEP and WHO, in collaboration with international experts, have taken a step forward by supporting the development of a main document on endocrine disruptors, including scientific information on their impacts on human and wildlife health, scientific developments over the decade since publication of the IPCS (2002) report and key concerns. The collaboration also included the development of the present summary report, which is aimed at decision-makers and others concerned about the future of human and wildlife health. The key concerns and main messages from the three chapters of the main document are also presented in this summary.

The main document provides an assessment of the strength of the evidence supporting the hypothesis that chemicals with endocrine activity are a causal factor in the manifestation of specific conditions.

The *State of the Science of Endocrine Disrupting Chemicals—2012* report starts by explaining what endocrine disruption is all about and then reviews our current knowledge of endocrine disrupting effects in humans and in wildlife. The document ends with a review of sources of and exposures to EDCs. The present *Summary for Decision-Makers* refers to the detailed information, including references, given in the main report (UNEP/WHO, 2012).

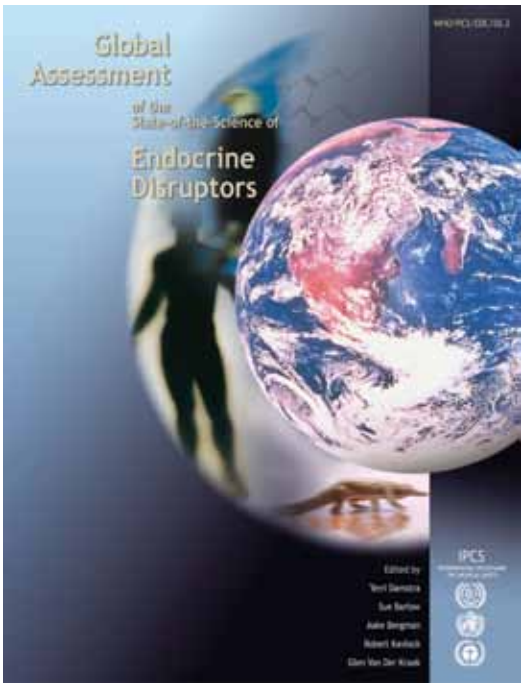


Figure 1. The *Global Assessment of the State-of-the-Science of Endocrine Disruptors* report, as published by IPCS in 2002.

2. Key concerns

- **Human and wildlife health depends on the ability to reproduce and develop normally. This is not possible without a healthy endocrine system.**
- **Three strands of evidence fuel concerns over endocrine disruptors:**
  - The high incidence and the increasing trends of many endocrine-related disorders in humans;
  - Observations of endocrine-related effects in wildlife populations;
  - The identification of chemicals with endocrine disrupting properties linked to disease outcomes in laboratory studies.
- **Many endocrine-related diseases and disorders are on the rise.**
  - Large proportions (up to 40%) of young men in some countries have low semen quality, which reduces their ability to father children.
  - The incidence of genital malformations, such as non-descending testes (cryptorchidisms) and penile malformations (hypospadias), in baby boys has increased over time or levelled off at unfavourably high rates.
  - The incidence of adverse pregnancy outcomes, such as preterm birth and low birth weight, has increased in many countries.
  - Neurobehavioural disorders associated with thyroid disruption affect a high proportion of children in some countries and have increased over past decades.
  - Global rates of endocrine-related cancers (breast, endometrial, ovarian, prostate, testicular and thyroid) have been increasing over the past 40–50 years.
  - There is a trend towards earlier onset of breast development in young girls in all countries where this has been studied. This is a risk factor for breast cancer.
  - The prevalence of obesity and type 2 diabetes has dramatically increased worldwide over the last 40 years. WHO estimates that 1.5 billion adults worldwide are overweight or obese and that the number with type 2 diabetes increased from 153 million to 347 million between 1980 and 2008.
- **Close to 800 chemicals are known or suspected to be capable of interfering with hormone receptors, hormone synthesis or hormone conversion. However, only a small fraction of these chemicals have been investigated in tests capable of identifying overt endocrine effects in intact organisms.**
  - The vast majority of chemicals in current commercial use have not been tested at all.
  - This lack of data introduces significant uncertainties about the true extent of risks from chemicals that potentially could disrupt the endocrine system.
- **Human and wildlife populations all over the world are exposed to EDCs.**
  - There is global transport of many known and potential EDCs through natural processes as well as through commerce, leading to worldwide exposure.
  - Unlike 10 years ago, we now know that humans and wildlife are exposed to far more EDCs than just those that are persistent organic pollutants (POPs).
  - Levels of some newer POPs in humans and wildlife are still increasing, and there is also exposure to less persistent and less bioaccumulative, but ubiquitous, chemicals.
  - New sources of human exposure to EDCs and potential EDCs, in addition to food and drinking-water, have been identified.
  - Children can have higher exposures to chemicals compared with adults—for example, through their hand-to-mouth activity and higher metabolic rate.
- **The speed with which the increases in disease incidence have occurred in recent decades rules out genetic factors as the sole plausible explanation. Environmental and other non-genetic factors, including nutrition, age of mother, viral diseases and chemical exposures, are also at play, but are difficult to identify. Despite these difficulties, some associations have become apparent:**
  - Non-descended testes in young boys are linked with exposure to diethylstilbestrol (DES) and polybrominated diphenyl ethers (PBDEs) and with occupational pesticide exposure during pregnancy. Recent evidence also shows links with the painkiller paracetamol. However, there is little to suggest that polychlorinated biphenyls (PCBs) or dichlorodiphenyldichloroethylene (DDE) and dichlorodiphenyltrichloroethane (DDT) are associated with cryptorchidism.
  - High exposures to polychlorinated dioxins and certain PCBs (in women who lack some detoxifying enzymes) are risk factors in breast cancer. Although exposure to natural and synthetic estrogens is associated with breast cancer, similar evidence linking estrogenic environmental chemicals with the disease is not available.
  - Prostate cancer risks are related to occupational exposures to pesticides (of an unidentified nature), to some PCBs and to arsenic. Cadmium exposure has been linked with prostate cancer in some, but not all, epidemiological studies, although the associations are weak.

- Developmental neurotoxicity with negative impacts on brain development is linked with PCBs. Attention deficit/hyperactivity disorder (ADHD) is overrepresented in populations with elevated exposure to organophosphate pesticides. Other chemicals have not been investigated.
- An excess risk of thyroid cancer was observed among pesticide applicators and their wives, although the nature of the pesticides involved was not defined.

- **Significant knowledge gaps exist as to associations between exposures to EDCs and other endocrine diseases, as follows:**
  - There is very little epidemiological evidence to link EDC exposure with adverse pregnancy outcomes, early onset of breast development, obesity or diabetes.
  - There is almost no information about associations between EDC exposure and endometrial or ovarian cancer.
  - High accidental exposures to PCBs during fetal development or to dioxins in childhood increase the risk of reduced semen quality in adulthood. With the exception of these studies, there are no data sets that include information about fetal EDC exposures and adult measures of semen quality.
  - No studies exist that explore the potential link between fetal exposure to EDCs and the risk of testicular cancer occurring 20–40 years later.
- **Numerous laboratory studies support the idea that chemical exposures contribute to endocrine disorders in humans and wildlife. The most sensitive window of exposure to EDCs is during critical periods of development, such as during fetal development and puberty.**
  - Developmental exposures can cause changes that, while not evident as birth defects, can induce permanent changes that lead to increased incidence of diseases throughout life.
  - These insights from endocrine disruptor research in animals have an impact on current practice in toxicological testing and screening. Instead of solely studying effects of exposures in adulthood, the effects of exposures during sensitive windows in fetal development, perinatal life, childhood and puberty require careful scrutiny.
- **Worldwide, there has been a failure to adequately address the underlying environmental causes of trends in endocrine diseases and disorders.**
  - Health-care systems do not have mechanisms in place to address the contribution of environmental risk factors to endocrine disorders. The benefits that can be reaped by adopting primary preventive measures for dealing with these diseases and disorders have remained largely unrealized.
- **Wildlife populations have been affected by endocrine disruption, with negative impacts on growth and reproduction. These effects are widespread and have been due primarily to POPs. Bans of these chemicals have reduced exposure and led to recovery of some populations.**
  - It is therefore plausible that additional EDCs, which have been increasing in the environment and are of recent concern, are contributing to current population declines in wildlife species. Wildlife populations that are also challenged by other environmental stressors are particularly vulnerable to EDC exposures.
- **Internationally agreed and validated test methods for the identification of endocrine disruptors capture only a limited range of the known spectrum of endocrine disrupting effects. This increases the likelihood that harmful effects in humans and wildlife are being overlooked.**
  - For many endocrine disrupting effects, agreed and validated test methods do not exist, although scientific tools and laboratory methods are available.
  - For a large range of human health effects, such as female reproductive disorders and hormonal cancers, there are no viable laboratory models. This seriously hampers progress in understanding the full scale of risks.
- **Disease risk due to EDCs may be significantly underestimated.**
  - A focus on linking one EDC to one disease severely underestimates the disease risk from mixtures of EDCs. We know that humans and wildlife are simultaneously exposed to many EDCs; thus, the measurement of the linkage between exposure to mixtures of EDCs and disease or dysfunction is more physiologically relevant. In addition, it is likely that exposure to a single EDC may cause disease syndromes or multiple diseases, an area that has not been adequately studied.
- **An important focus should be on reducing exposures by a variety of mechanisms. Government actions to reduce exposures, while limited, have proven to be effective in specific cases (e.g. bans and restrictions on lead, chlorpyrifos, tributyltin, PCBs and some other POPs). This has contributed to decreases in the frequency of disorders in humans and wildlife.**
- **Despite substantial advances in our understanding of EDCs, uncertainties and knowledge gaps still exist that are too important to ignore. These knowledge gaps hamper progress towards better protection of the public and wildlife. An integrated, coordinated international effort is needed to define the role of EDCs in current declines in human and wildlife health and in wildlife populations.**

3. Endocrine systems and endocrine disruption

For the purposes of this report, we have adopted the definition of an endocrine disruptor that was used in the IPCS (2002) document on endocrine disruptors (see textbox). Simplified, this means that endocrine disruptors are chemicals, or chemical mixtures, that interfere with normal hormone action.

To understand endocrine disruption, we must understand the basic features of the endocrine system, which consists of many interacting tissues that talk to each other and the rest of the body using signalling mediated by molecules called hormones. The human endocrine system is visualized in **Figure 2**. It is responsible for controlling a large number of processes in the body, including early processes, such as cell differentiation during development and organ formation, as well as most tissue and organ functions throughout adulthood (**Figure 3**). A hormone is a molecule produced by an endocrine gland that travels through the blood to produce effects on distant cells and tissues via integrated complex interacting signalling pathways usually involving hormone receptors. There are over 50 different hormones and hormone-related molecules (cytokines and neurotransmitters) in humans that integrate and control normal body functions across and between tissues and organs over the lifespan. This is also the case in wildlife. Hormones and their signalling pathways are critical to the normal functioning of every tissue and organ in both vertebrates and invertebrates and are often quite similar across species.

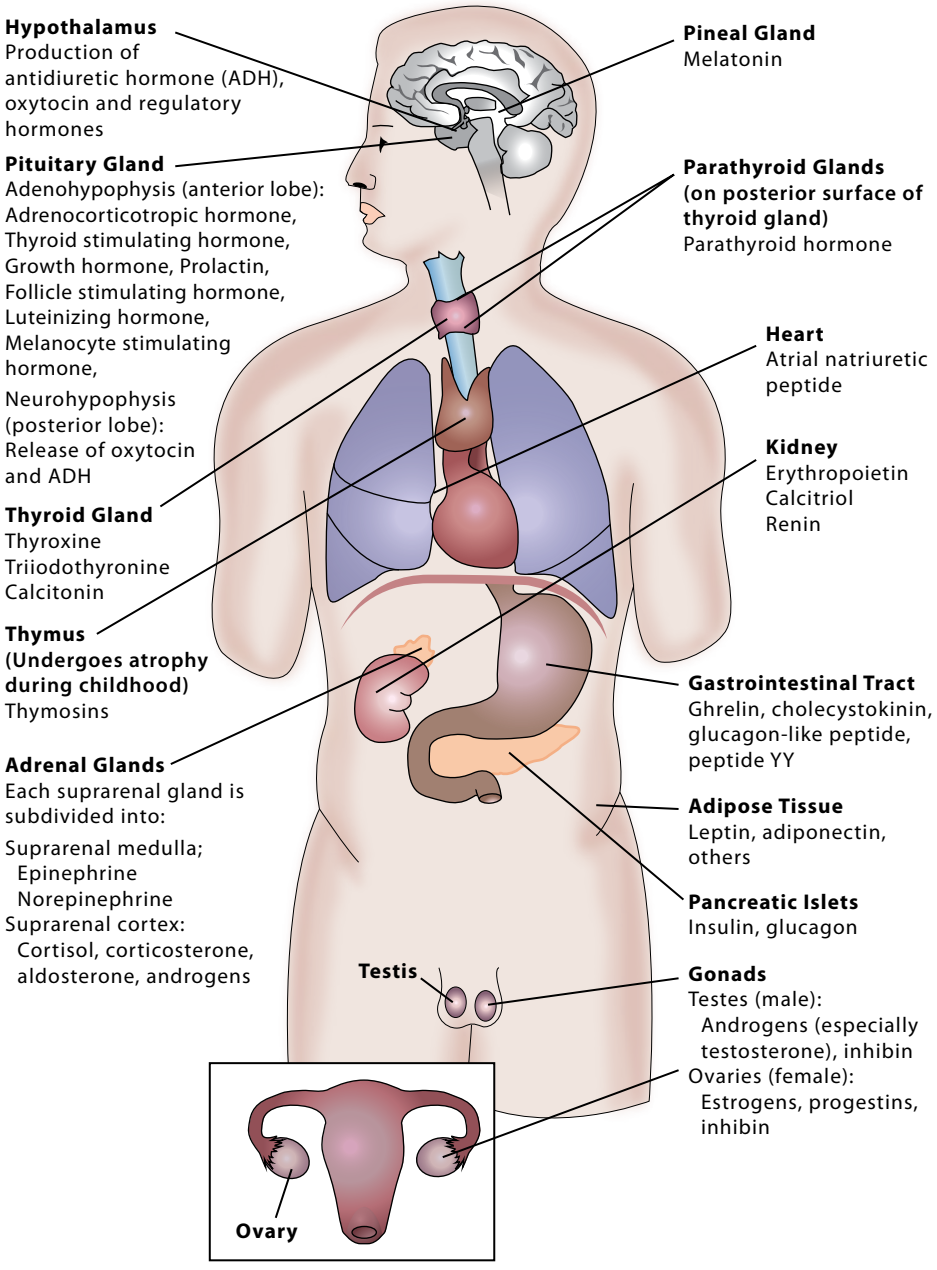


Figure 2. Overview of the endocrine system. Figure shows endocrine glands and some examples of hormones produced.

Definition of EDCs (IPCS, 2002)

*"An **endocrine disruptor** is an exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub) populations."*

*"A **potential endocrine disruptor** is an exogenous substance or mixture that possesses properties that might be expected to lead to endocrine disruption in an intact organism, or its progeny, or (sub) populations."*

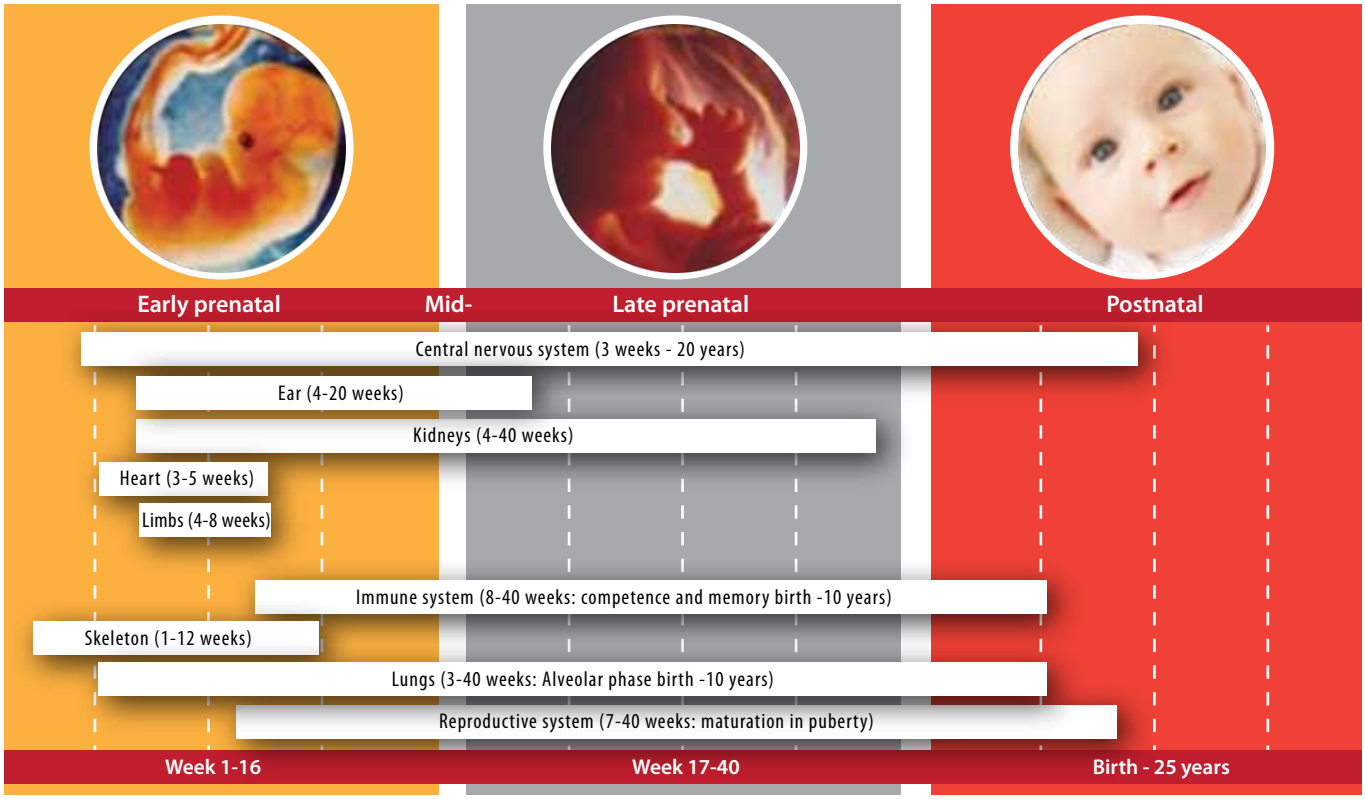


Figure 3. Sensitive windows of development. Each tissue has a specific window during development when it is forming. That is the sensitive window for effects of EDCs. Notice that some tissues continue developing after birth and into infancy and childhood, providing a longer window for exposures to affect programming.

Table 1. Comparison of hormone and endocrine disruptor action.

Hormones	Endocrine disruptors
Act via hormone receptors – Some have multiple receptors – Tissue-specific receptor classes and subtypes – Hormones normally bind similarly to all receptor subtypes	Some act via hormone receptors and multiple receptors – Will cause abnormal receptor function – Likely isoform-specific interactions
Active at low doses – Blood levels do not always reflect activity – May be bound to serum proteins in blood with a small percentage free – No bioaccumulation	Some act at low doses, others variable – Blood levels do not always reflect activity – May be bound to serum proteins – Effects on hormone blood levels may not reflect on hormone action – Possible bioaccumulation
Non-linear dose–response relationships – Always saturable with variable dynamic range – Can exhibit non-monotonic dose–response relationships – High-dose effects not same as low-dose effects	Non-linear dose–response relationships – Always saturable with variable dynamic range – Can exhibit non-monotonic dose–response relationships – High-dose effects not same as low-dose effects
Tissue-specific and life stage–specific effects	Tissue-specific and life stage–specific effects
Developmental effects permanent – Programmes brain and endocrine system for adult function	Developmental effects permanent – Interferes with programming processes
Different end-points vary in sensitivity	Different end-points vary in sensitivity

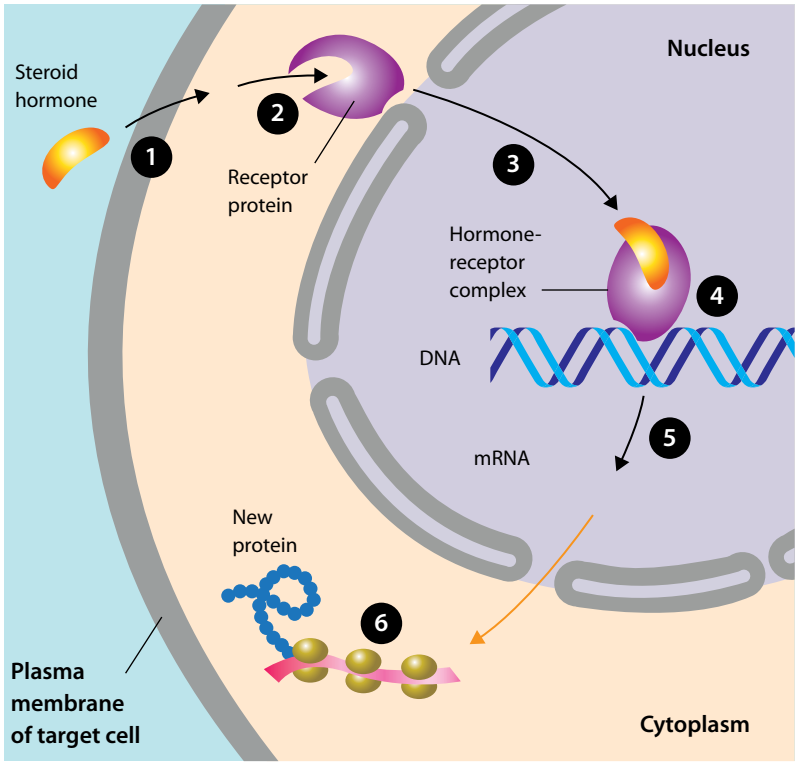


Figure 4. Example of hormone action. Many hormones act via binding to specific receptors (2) to stimulate the synthesis of new proteins (6), which then control tissue function. Some hormones also act via receptors on the membrane; in that case, the actions are more immediate in nature.

Endocrine disruptors are chemicals that interfere in some way with hormone action and in so doing can alter endocrine function such that it leads to adverse effects on human and wildlife health.

The diverse systems affected by EDCs likely include all hormonal systems and range from those controlling the development and function of reproductive organs to the tissues and organs regulating metabolism and satiety. Effects on these systems can lead to obesity, infertility or reduced fertility, learning and memory difficulties, adult-onset diabetes or cardiovascular disease, as well as a variety of other diseases. We have only recently understood that EDCs can affect the systems that control fat development and weight gain. This is a good example of complex physiological systems that are influenced by EDCs that were not known just a few years ago. Generally, there are two pathways by which a chemical could disrupt hormone action: a direct action on a hormone–receptor protein complex or a direct action on a specific protein that controls some aspect of hormone delivery to the right place at the right time (**Figure 3**). EDCs exhibit the same characteristics as hormones (**Table 1**), and they can often interfere with all processes controlled by hormones. The affinity of an endocrine disruptor for a hormone receptor is not equivalent to its potency. Chemical potency on a hormone system is dependent upon many factors.

Thus, EDCs act like hormones. Like hormones, which act via binding to receptors (**Figure 4**) at very low concentrations, EDCs have the ability to be active at low concentrations, many in the range of current human and wildlife exposures. EDCs can exert effects on more than estrogen, androgen and thyroid hormone action. Some are known to interact with multiple hormone receptors simultaneously. EDCs can work together to produce additive or synergistic effects not seen with the individual chemicals. EDCs also act on a variety of physiological processes in a tissue-specific manner and sometimes act via dose–response curves that are non-monotonic (non-linear). Indeed, as with hormones, it is often not possible to extrapolate low-dose effects from the high-dose effects of EDCs. Timing of exposures is also critical, as exposures during development likely lead to irreversible effects, whereas the effects of adult exposures seem to go away when the EDC is removed. Sensitivity to endocrine disruption is highest during tissue development. It is important that these specific characteristics of EDCs be taken into account when the toxicity of a chemical with potential EDC activity is assessed.

4. Endocrine disruptors and human health

The data linking exposures to EDCs and human diseases are much stronger now than in 2002. Since human studies can show associations only, not cause and effect, it is important to use both human and animal data to develop the evidence for a link between exposures to EDCs and human disease. Even so, it may never be possible to be absolutely certain that a specific exposure causes a specific disease or dysfunction due to the complexity of both exposures and disease etiology across the lifespan (**Figure 5**).

• Reproductive/endocrine
- Breast/prostate cancer
- Endometriosis
- Infertility
- Diabetes/metabolic syndrome
- Early puberty
- Obesity

• Immune/autoimmune
- Susceptibility to infections
- Autoimmune disease

• Cardiopulmonary
- Asthma
- Heart disease/hypertension
- Stroke

• Brain/nervous system
- Alzheimer disease
- Parkinson disease
- ADHD/learning disabilities

Figure 5. Diseases induced by exposure to EDCs during development in animal model and human studies.

Over the past 10 years, there has been a dramatic shift in focus from investigating associations between adult exposures to EDCs and disease outcomes to linking developmental exposures to disease outcomes later in life. This is now considered the most appropriate approach for most endocrine-related diseases and dysfunctions, based on data presented below (section 8). Children are the most vulnerable humans (**Figure 6**).

Together, the animal model data and human evidence support the idea that exposure to EDCs during fetal development and puberty plays a role in the increased incidences of reproductive diseases, endocrine-related cancers, behavioural and learning problems, including ADHD, infections, asthma, and perhaps obesity and diabetes in humans.

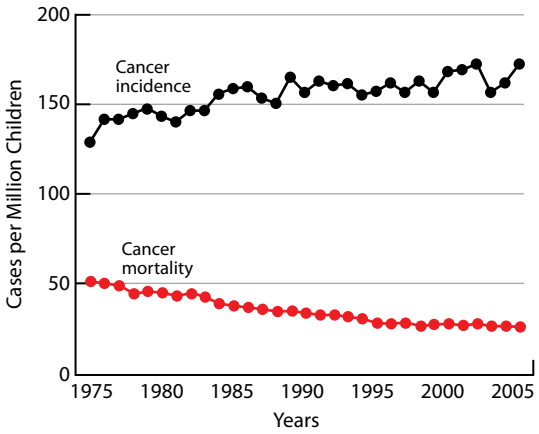


Figure 6. Children are among the most vulnerable humans. The figure shows cancer incidence and cancer mortality among children under 20 years of age in the USA (based on data from the United States National Cancer Institute's Surveillance, Epidemiology and End Results Program).

EXPOSURE TO EDCS COULD IMPAIR THE HEALTH OF OUR CHILDREN AND THEIR CHILDREN.

5. Why should we be concerned?—Human disease trends

- A significant increase in reproductive problems in some regions of the world over the last few decades points to a strong role for unidentified environmental factors in disease etiology.
- Incidences of endocrine cancers, illustrated by country or region in **Figures 7 and 8** for testicular cancer and breast cancer, respectively, have also increased during the same period.
- In certain parts of the world, there has been a significant decrease in human fertility rates, which occurred during one generation. There is also a notable rise in the use of assisted reproductive services.
- An increasing number of chemicals to which all humans in industrialized areas are exposed have been shown to interfere with hormone synthesis, action or metabolism.
- Experimental animal studies or studies with cells grown in culture have shown that many of these chemicals can also interfere with the development and function of mammalian endocrine systems.

In adults, EDC exposures have recently been linked with obesity (**Figure 9**), cardiovascular disease, diabetes and metabolic syndrome. Many of these diseases and disorders are increasing in incidence, some globally. The global health expenditure on diabetes alone was expected to a total of at least 376 billion USD in 2010 and rise to US$ 490 billion in 2030—reaching 12% of all per capita health-care expenditures (Zhang et al., 2010).

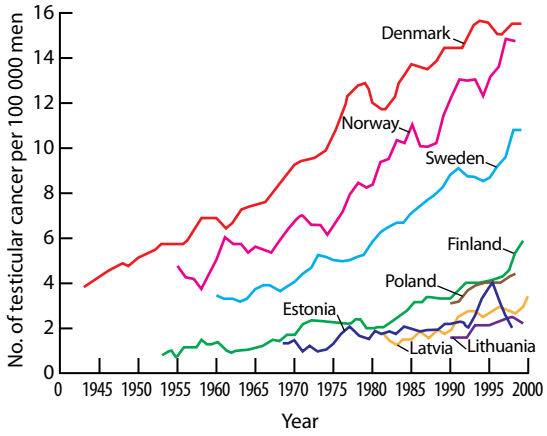


Figure 7. Testicular cancer rates across northern Europe (from Richiardi et al., 2004; used with permission of the publisher).

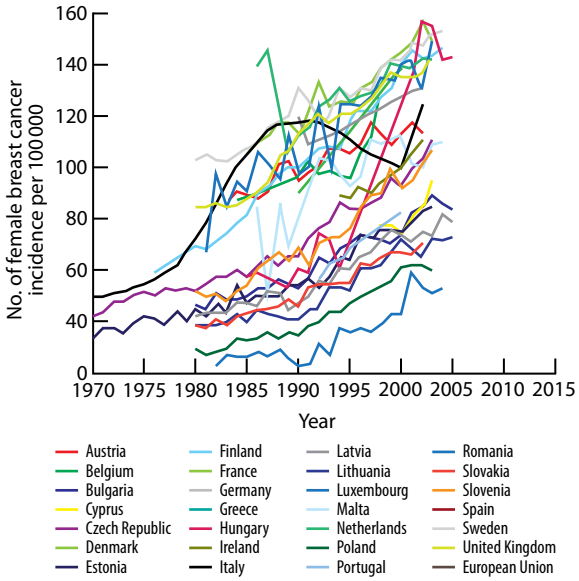


Figure 8. Female breast cancer incidence across Europe (data from http://data.euro.who.int/hfadb/).

There are other trends of concern in human paediatric health. For example, some EDCs can interact with the thyroid system in animals and humans. Normal thyroid function is very important for normal brain development, particularly during pregnancy and after birth. EDC exposures have been linked with increased rates of neurobehavioural disorders, including dyslexia, mental retardation, ADHD and autism. In many countries, these types of disorder now affect 5–10% of babies born (http://www.medscape.org/viewarticle/547415_2); autism spectrum disorders now occur at a rate that approaches 1% (http://www.cdc.gov/ncbddd/autism/addm.html).

The prevalence of paediatric asthma has more than doubled over the past 20 years and is now the leading cause of child hospitalizations and school absenteeism. Certain birth defects, such as those of the male reproductive organs (e.g. failure of the testes to descend into the scrotum), are on the rise. The incidences of paediatric leukaemia and brain cancer have risen, as has the incidence of testicular cancer. These are stark health statistics. All of these complex non-communicable diseases have both a genetic and an environmental component, and, since the increases in incidence and prevalence cannot be due solely to genetics, it is important to focus on understanding the contribution of the environment to these chronic disease trends in humans.

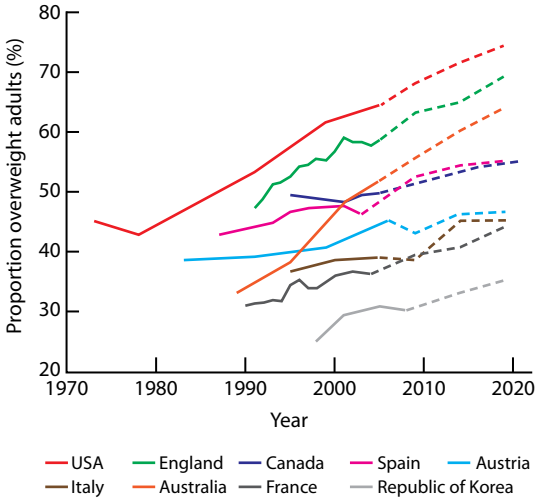


Figure 9. Past (solid lines) and projected (dashed lines) overweight rates in selected Organisation for Economic Co-operation and Development (OECD) countries.

It has been estimated that as much as 24% of human diseases and disorders are at least in part due to environmental factors (Prüss-Üstün & Corvalán, 2006). It is a challenge to identify these factors, but there is also a tremendous opportunity to improve human health by improving elements of the environment that have an impact on public health. The recognition of these challenges and opportunities, along with the fact that many of the most prevalent diseases are associated with the endocrine system, has led to a focus on EDCs.

6. Endocrine disruptors and wildlife health

Chemical exposures play a role in the deterioration of wildlife health, but understanding the role of EDCs in the global decline of populations or biodiversity is challenging. There are other natural or human-induced stressors that may confuse the picture. It is also difficult to obtain complete information about all chemicals present in the environment that might contribute to effects on wildlife. The best evidence that EDCs affect wildlife populations comes from long-term monitoring; for example, numbers of birds and molluscs are clearly increasing in regions where their exposures to chemicals (i.e. the pesticide DDT and the antifoulant tributyltin, respectively) have been reduced.

Figure 10. (right) Grey seal skull with highly eroded bone tissue associated with high POP concentrations during the 1970s and 1980s (photo by Hans Lind, used with permission).

Endocrine system function and health have been compromised in wildlife species around the world. Studies of seals in the heavily polluted Baltic Sea found very high rates of female reproductive pathologies and reproductive failure in the 1970s and 1980s, which correlated with PCB contamination. Thanks to declines in PCB pollution, these effects are uncommon today. Disturbances of the normal functioning of the thyroid and of bone health have been traced to high POP levels in grey seals (**Figure 10**). In Dutch and Belgian colonies of common tern, eggs with higher concentrations of POPs took longer to hatch, and the chicks were smaller in size. Especially in the United Kingdom, but also in other countries, fish have been widely affected by estrogens and anti-androgens in municipal wastewaters. In male fish, increased levels of the female egg yolk proteins and the occurrence of eggs in the testes have been the consequence. The antifouling agent tributyltin in ship paints has disrupted mollusc sexual development worldwide (**Figure 11**). By the 1970s, many populations of species, such as the commercially important oyster, had collapsed in heavily polluted areas. Reductions in use and exposure have led to a recovery of these populations.

There are important parallels between the increasing incidence of human disorders and those observed in wildlife. For example, testicular non-descent was observed in 68% of males in a population of black-tailed deer in Alaska, USA; similar trends were also observed in Montana, USA. There is recent evidence that animals living near humans also have increasing body weight. Moreover, studies of PCB-exposed wildlife have provided important information on exposure levels, early and subclinical effects and the clinical neurotoxicity of these chemicals. The mechanisms underlying the effects and the outcomes of exposures are often similar to those in humans.

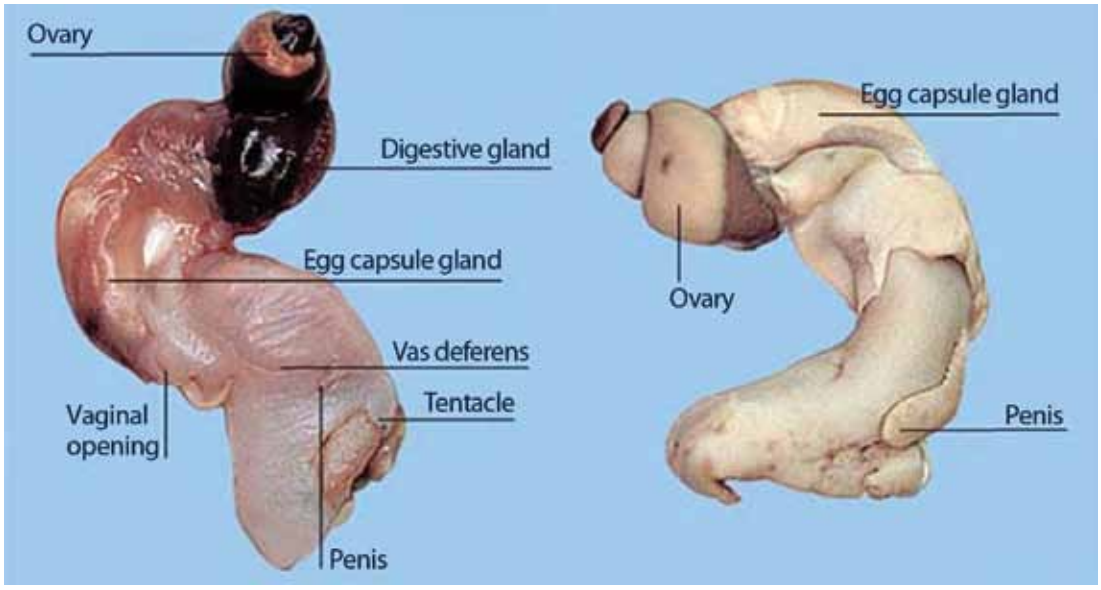


Figure 11. Common whelk (*Buccinum undatum*) showing imposex (i.e. it has both male and female genitalia).

7. Why should we be concerned?—Population effects in wildlife

- There is a worldwide loss of species or reduced population numbers of amphibians, mammals, birds, reptiles, freshwater and marine fishes (**Figure 12**) and invertebrates.
- EDCs have been shown to negatively affect body systems that are critical for the health and survival of wildlife.
- The current body burdens of POPs such as PCBs, organochlorine pesticides and methylmercury in some fish-eating birds and marine mammal populations are at levels known to cause effects on breeding and on the immune system (**Figure 13**). Some of these populations are threatened or endangered.
- Legal, technical and ethical constraints to working with wildlife, notably those listed under endangered species legislation, prevent research to investigate chemical causes of population declines in these animals.
- An increasing number of chemicals to which wildlife are exposed have been shown to interfere with the hormonal and immune systems of wildlife species. Most of these chemicals are not monitored in ecosystems. Exposed wildlife populations are often not monitored either.
- Experimental animal studies have shown that many chemicals can interfere with the development and function of endocrine systems, leading to effects on behaviour, fecundity, growth, survival and disease resistance. This increases the probability that exposure to EDCs could lead to population-level effects in wildlife.

Subtle effects of EDCs on individual animals may result in devastating effects on wildlife populations over the long term. This is hard to prove until the declines in populations are evident, at which point it may be too late to save these species.

Exposures to EDCs affect the reproductive health of wildlife species, but there have been few studies translating these effects to impacts at the population level. Notwithstanding this, higher rates of reproductive problems are found in animals with higher exposure to EDCs than in those exposed to lower concentrations. As levels of EDCs decline, some wildlife populations have shown recovery. EDCs have affected immune function, resulting in increased susceptibility to infectious diseases in vertebrates, notably marine mammals. Taken together, the evidence shows that exposure to endocrine disrupting contaminants plays a significant role in wildlife health trends.

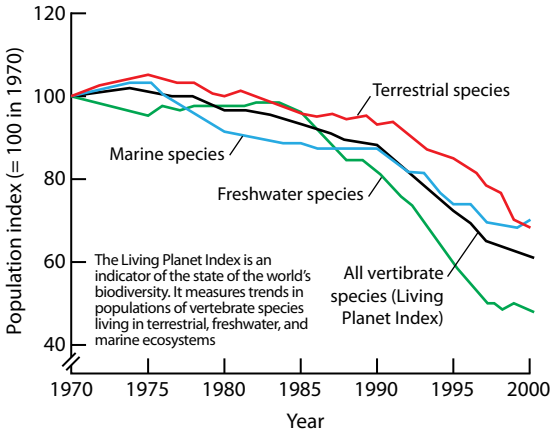


Figure 12. Population declines in wildlife (vertebrates) over 30 years, 1970–2000 (source: World Wide Fund for Nature [WWF] and the World Conservation Monitoring Centre of UNEP, used with permission).

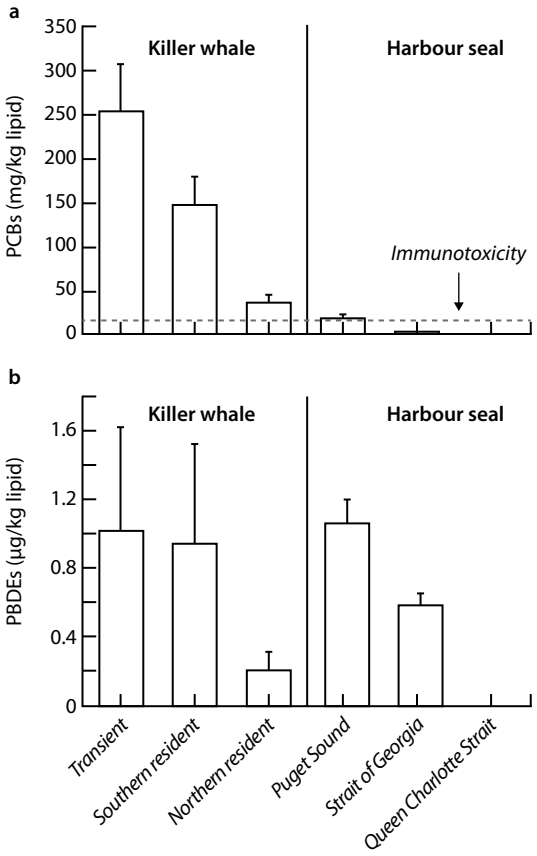


Figure 13. British Columbia's (Canada) killer whales (*Orcinus orca*) and harbour seals (*Phoca vitulina*) contain high levels of regulated PCBs and moderate levels of PBDEs. The figure was prepared using data from Krahn et al. (2007), Rayne et al. (2004) and Ross et al. (2000, 2012).

WILDLIFE ACROSS THE GLOBE DISPLAY EDC-RELATED REPRODUCTIVE EFFECTS.

8. Sensitive periods for endocrine disruptor action—Windows of exposure

Hormones and EDCs that alter hormone actions can act at all times during life—fetal development, infancy, early childhood, puberty, adulthood and old age. The timing of hormone or EDC action often determines the strength of their impact. In the adult, the hormone or EDC has an effect when it is present, but when the hormone or EDC is withdrawn, the effect diminishes—much like insulin levels rising when blood sugar is high and then declining when blood sugar declines.

In contrast, exposure to hormones or EDCs during development (in utero and infancy and early childhood in humans) can have permanent effects if the exposure occurs during the period when a specific tissue is developing. These effects may only become visible decades later. This is called developmental programming. Hormones control the normal development of tissues from the fertilized sperm and egg to the fully developed fetus. Since some tissues continue developing after birth—such as the brain and reproductive system—the sensitive period for these tissues is extended, sometimes for decades after birth.

When a tissue is developing, it is more sensitive to the action of hormones and thus EDCs.

The mechanisms by which EDC exposure during development can alter the development of specific tissues, leading to increased susceptibility to diseases later in life, are just beginning to be understood. It is clear that hormones play an important role in cell differentiation, which leads to the development of tissues and organs. Once tissues and organs are fully developed and active, then hormones have a different role: to control the integration of signals between tissues and organ systems and to maintain normal function. Early development (when hormones are controlling cell changes to form tissues and organs) is thus a very sensitive time frame for EDC action. If an EDC is present during the developmental programming of a tissue, it could disrupt the normal hormone levels, leading to changes in tissue development—changes that would be stable across the lifetime and possibly confer sensitivity to disease later in life. These effects

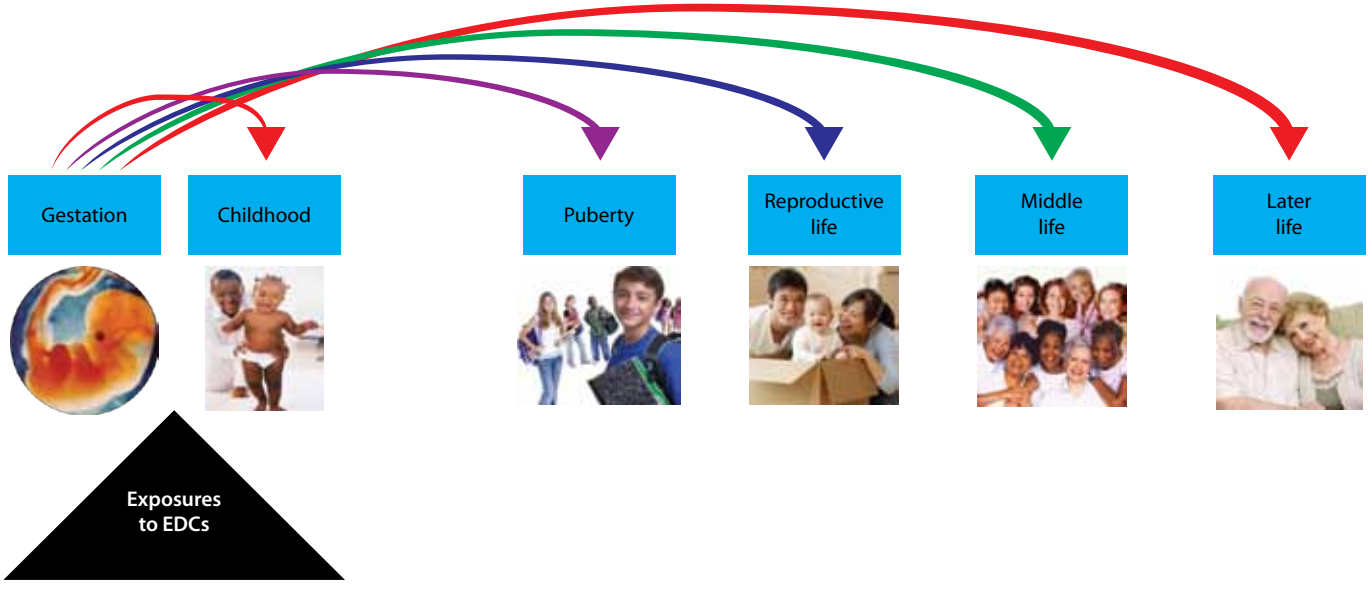


Figure 14. The effects of early exposures to EDCs may be manifested any time in life.

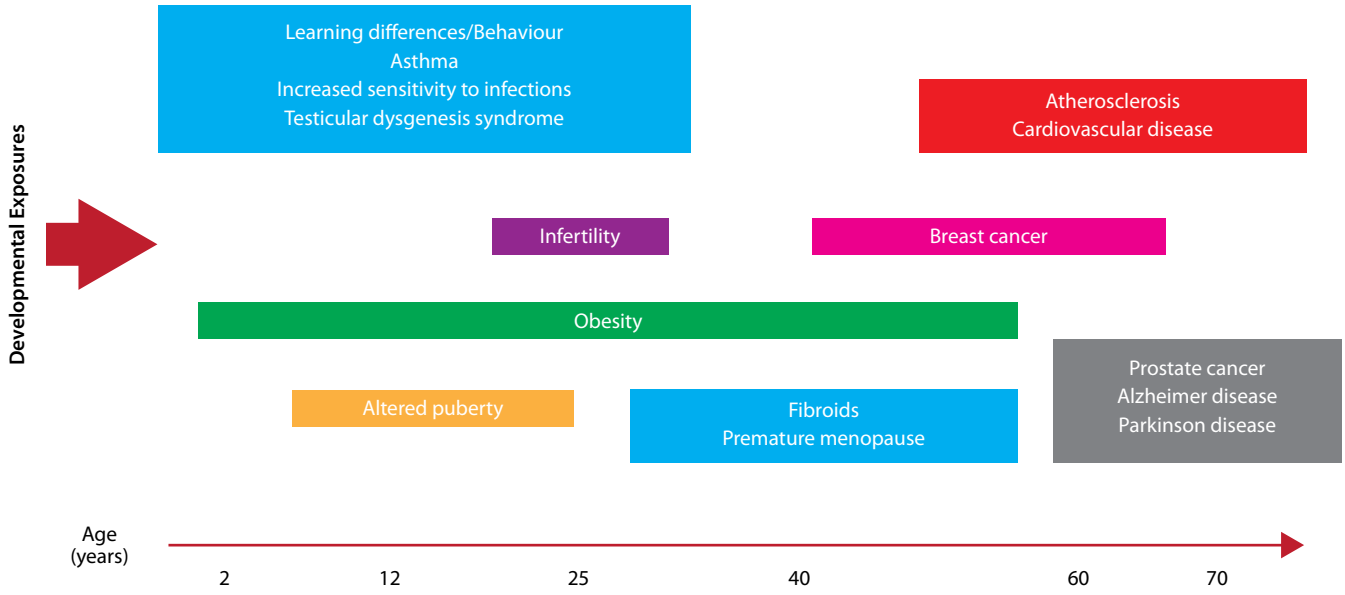


Figure 15. Examples of potential diseases and dysfunctions originating from early exposures to EDCs.

are not likely to be evident at birth, but may show up only later in life, from a few months to decades later (**Figures 14** and **15**). These developmental effects emphasize that babies and children are not just little adults!

Some EDCs produce effects that can cross generations (transgenerational effects), such that exposure of a pregnant woman or wild animal may affect not only the development of her offspring but also their offspring over several generations. This means that the increase in disease rates we are seeing today could in part be due to exposures of our grandparents to EDCs, and these effects could increase over each generation due to both transgenerational transmission of the altered programming and continued exposure across generations.

9. Occurrence of and exposures to endocrine disruptors

Since 2002, a large number of chemicals other than POPs have been identified as EDCs, and these include chemicals that have very different properties, sources and fates in the environment compared with POPs. EDCs are both man-made and natural. Some are found in a large variety of materials, products, articles and goods. They may also be by-products formed during manufacturing or combustion of wastes. These chemicals are also subjected to biological and environmental transformations that may form other EDCs. EDCs are found among many classes of chemicals, including POPs, current-use pesticides, phytoestrogens, metals, active ingredients in pharmaceuticals, and additives or contaminants in food, personal care products, cosmetics, plastics, textiles and construction materials. Once released into the environment, the more persistent chemicals can be carried by air and water currents to remote locations, and many can be biomagnified through food webs to high levels in humans and other top predators. Other chemicals have shorter lifespans in the environment but are regularly released in effluents, in agricultural runoff or from urban environments, resulting in high environmental levels near the sources (**Figure 16**).

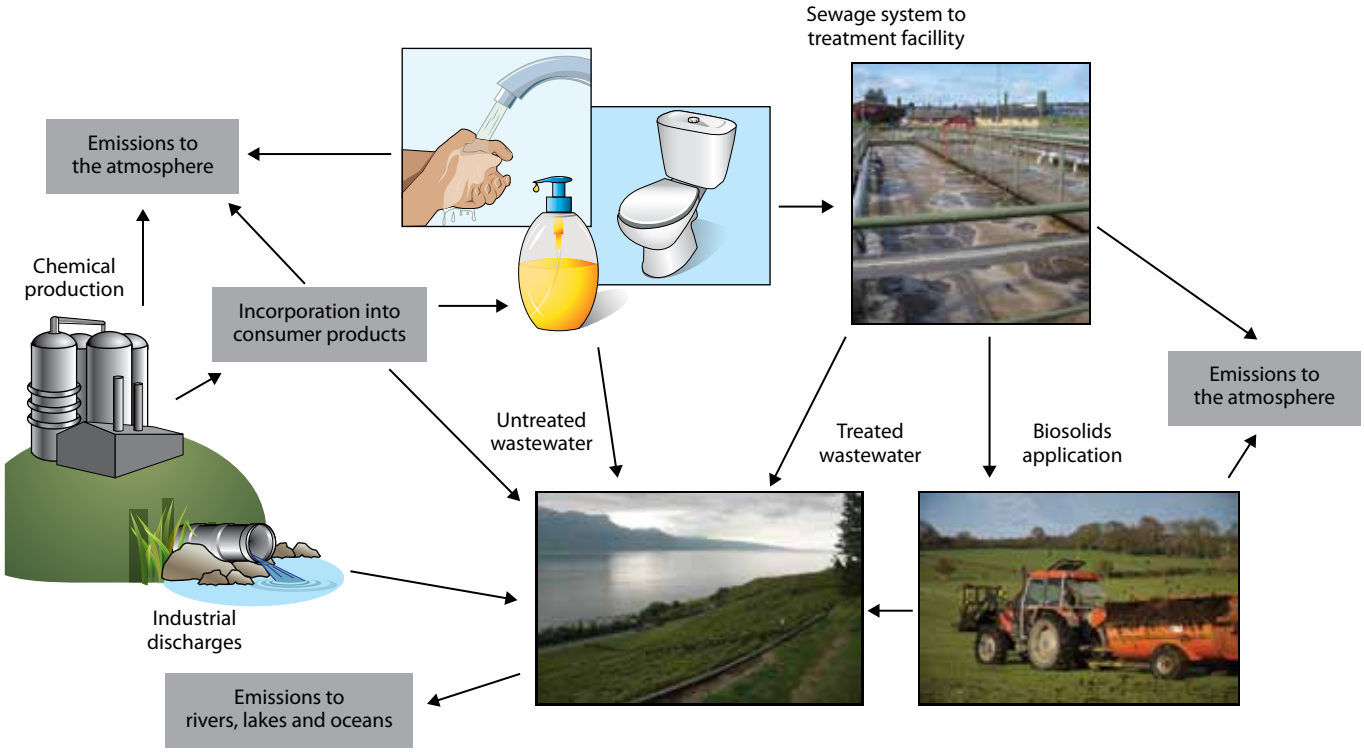


Figure 16. EDCs find their way into the environment via point and diffuse sources, as illustrated here.

Wildlife and humans are exposed to EDCs in several different ways. Air, water, soil, sediment and food are sources of EDCs for wildlife. Human exposure to EDCs occurs via ingestion of food, dust and water, via inhalation of gases and particles in the air and through dermal uptake (**Figure 17**). Transfer of EDCs from the pregnant female to the developing fetus through the placenta and to offspring in mothers' milk also occurs in both wildlife and humans. Children can have higher exposures to EDCs because of their hand-to-mouth activities. These multiple routes of exposure to a variety of EDCs mean that humans and wildlife are exposed to complex mixtures of EDCs. At this time, there are no data showing how exposure to mixtures of virtually hundreds of EDCs at low concentrations will affect human and wildlife health. However, animal studies show that exposures to mixtures of EDCs produce additive effects. These additive effects occur even when each chemical is present at low levels not shown to produce effects individually. This means that many chemicals, each at levels without individual effect, could act together to cause health problems.

Several hundred environmental pollutants have been measured in humans and wildlife around the world, even in remote places such as the Arctic. Levels of EDCs in humans and wildlife vary with their location; some are higher in people and wildlife in urban or highly industrialized areas or sites where, for example, disposal of e-waste occurs, whereas others are higher in remote environments because of long-range

Figure 17. EDCs from multiple sources can be taken up by humans by several routes, entering the body via ingestion, inhalation and skin uptake.

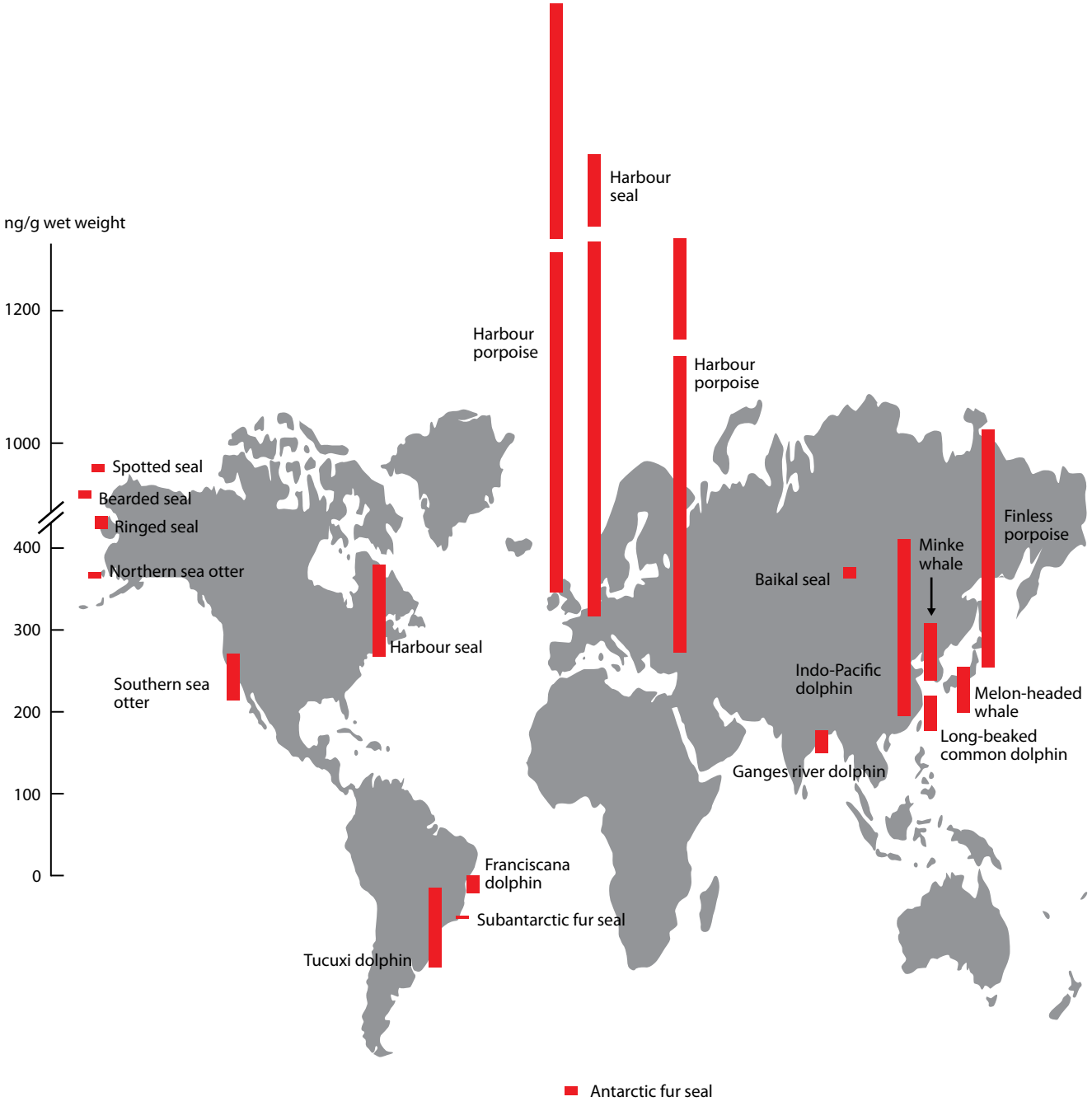


Figure 18. EDCs are found in wildlife worldwide. This figure shows concentrations (in ng/g wet weight) of perfluorooctane sulfonate, also known as PFOS, in liver of marine mammals (modified from Houde et al., 2011).

transport by air and ocean currents and food web accumulation. A few examples of exposure of wildlife around the world are shown in **Figures 18** and **19**. There are no longer any pristine areas without environmental pollutants. In addition, levels of chemicals in the body are tightly linked to trends in their use. There are good examples where bans or reductions in chemical use have resulted in reduced levels in humans and wildlife. Indeed, human and animal tissue concentrations of many POPs have declined because the chemicals are being phased out following global bans on their use. In contrast, EDCs that are being used more now are found at higher levels in humans and wildlife. It is notable how well production and exposure mirror each other, as exemplified in **Figure 20**.

Hundreds of chemicals in commerce are known to have endocrine disrupting effects. However, thousands of other chemicals with potential endocrine effects have not been looked for or tested. It is likely that these chemicals are contributing to wildlife and human exposures to EDCs. The situation is illustrated in **Figure 21**. Since only a very limited number of all chemicals in commerce have been tested for their endocrine disrupting properties, there may be many more with such properties. Also, the EDC metabolites or environmental transformation products and the by-products and products formed upon waste treatment are not included in these estimates, and their endocrine disrupting effects are mainly unknown.

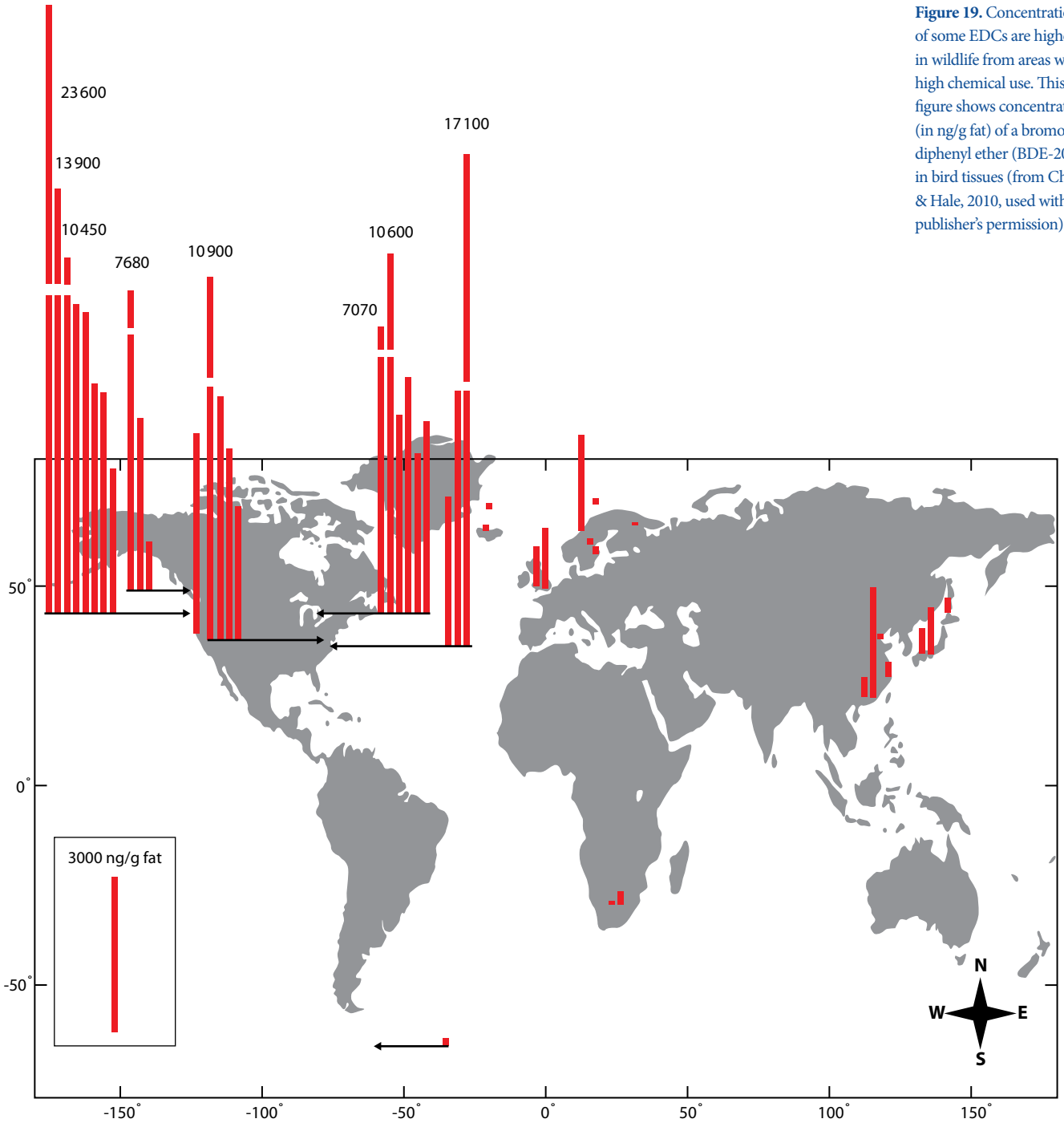
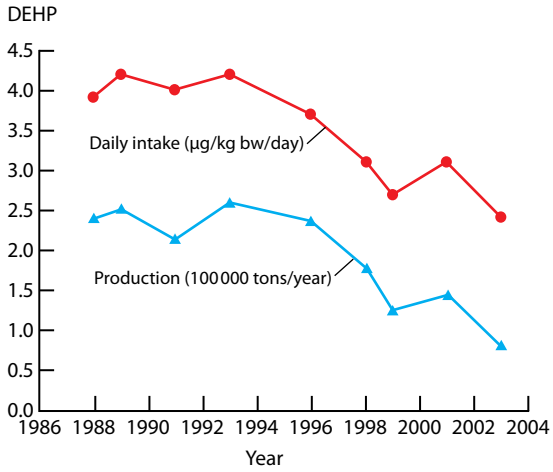


Figure 19. Concentrations of some EDCs are highest in wildlife from areas with high chemical use. This figure shows concentrations (in ng/g fat) of a bromo-diphenyl ether (BDE-209) in bird tissues (from Chen & Hale, 2010, used with publisher's permission).



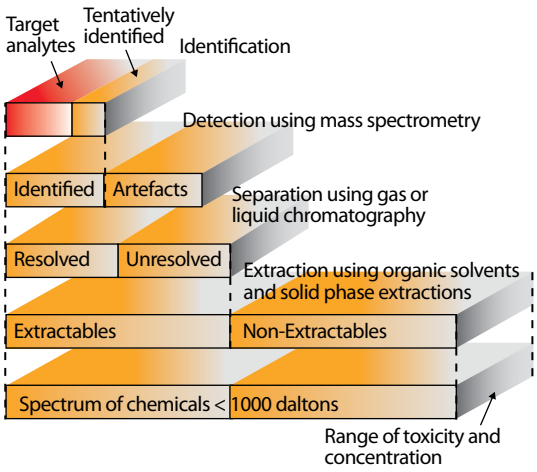


Figure 20. (left) Time course of industrial di(2-ethylhexyl)phthalate (DEHP) production in Germany, and median daily intake of DEHP in university students (from Helm, 2007, used with publisher's permission).

Figure 21. (right) An illustration of the complexity of measuring chemicals, including potential EDCs, in environmental media.

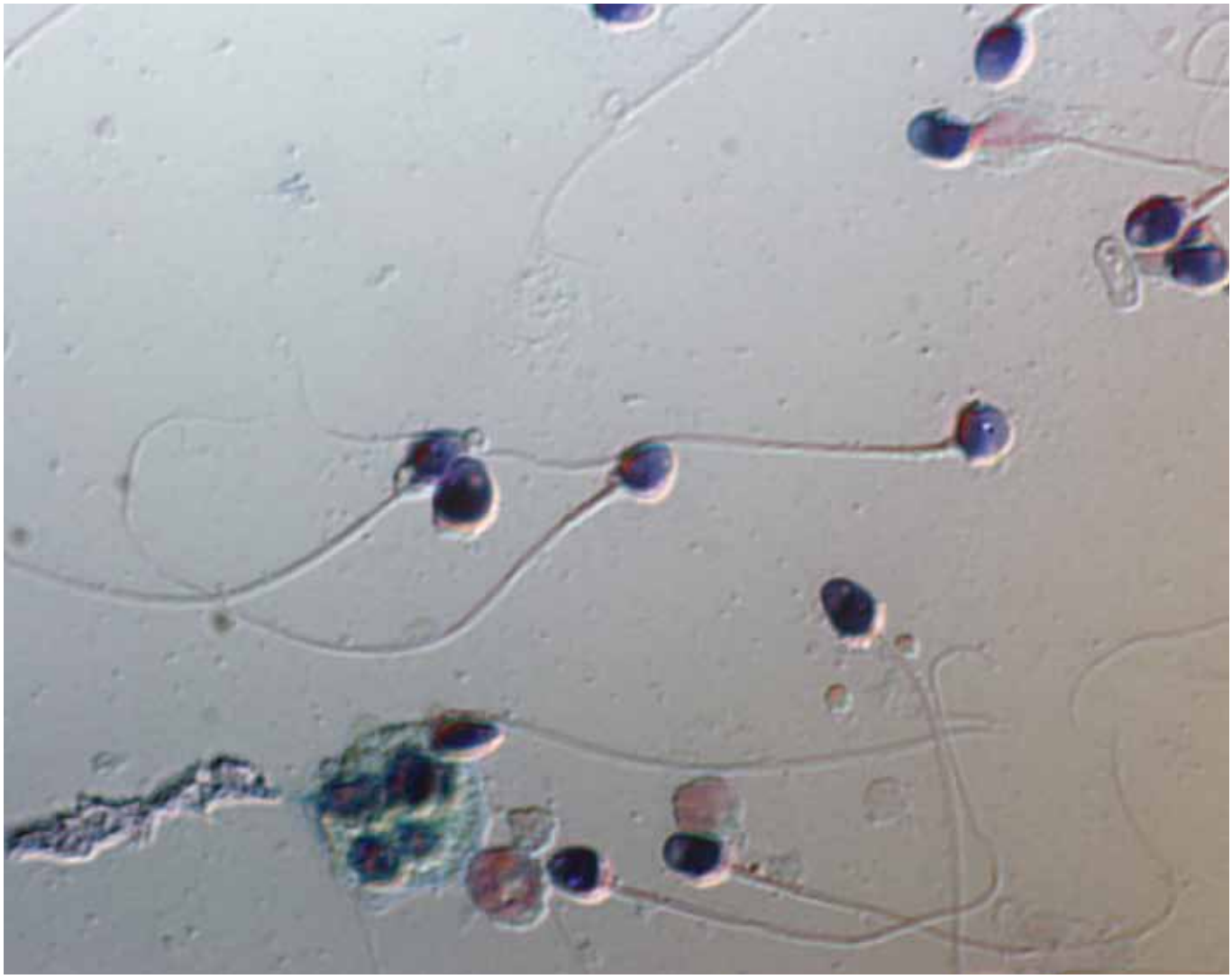
10. The tip of the iceberg

Because only a small fraction of the hundreds of thousands of synthetic chemicals in existence have been assessed for endocrine disrupting activity, and because many chemicals in consumer products are not identified by the manufacturer, we have only looked at the "tip of the iceberg". How many EDCs are there? Where do they come from? What are the human and wildlife exposures? What are their effects individually and in mixtures during development and adulthood and even across generations? What are their mechanisms of action? How can testing for EDCs be improved? All of these questions need answers.

11. Testing for EDCs

Since there are data from epidemiological studies showing associations between human disease end-points and EDC exposures, it is likely that endocrine diseases and disorders are occurring at current exposure levels. Put another way, this means that there are situations in which individually safe exposures of EDCs have reached a collectively harmful level or in which levels thought to be safe are not so.

When chemicals are tested for endocrine disrupting activity under specific validated guideline studies, it is customary to examine three doses to determine a level not apparently associated with observable effects. This level, termed the no-observed-adverse-effect level, is then divided by a so-called safety or uncertainty factor (of 100, for example) to extrapolate to levels expected to be safe for humans or wildlife. The doses declared safe are not actually tested, nor are the mixtures. These studies also assume that there is a threshold for EDC effects, that there will be no effects at low doses and that the dose–response curve rises with increasing dose. As noted above, there is no threshold for EDC effects due to the presence of active hormone pathways, and EDCs are likely to have effects at low doses. Consequently, their dose–response curves will not necessarily rise in proportion to dose. Regulatory guideline studies also focus on histopathology and organ and body weights as the end-points. As noted above, EDCs can cause many diseases and affect many disease end-points that are not currently assessed in regulatory studies. Also, risk assessment approaches do not always assess toxicity during development, which is the most sensitive window for EDC action, and also do not follow the animals for their lifetime, which is needed to assess resulting diseases.



12. Lessons from the past

How can society protect our health and that of future generations from the actions of EDCs? What can we learn from the past that will help us?

One option is to ban a chemical shown to cause toxicity and disease. Over the last 40 years, only a handful of chemicals—e.g. lead, POPs, tributyltin, di(2-ethylhexyl)phthalate, nonylphenol and chlorpyrifos—have been banned in many countries, and sometimes these bans concern specific uses only. Nonetheless, there have been clear benefits for human and wildlife health from the declining use of these chemicals.

One of the best examples of positive action is the banning of residential use of the organophosphate insecticide chlorpyrifos in the USA in 2000. Chlorpyrifos has been shown to be a potent neurotoxicant, causing developmental delays, attention problems and ADHD in children. Today, the manufacturer in question has phased out products for residential uses around the world; the chemical is still used professionally worldwide as an insecticide on fruits and vegetables in commercial agriculture. Following the residential ban in the USA, children's blood levels in New York declined significantly within one year and were reduced to less than half within two years.

Tributyltin is particularly interesting, as it was banned from use on ship hulls due to its reproductive effects on molluscs. In harbours where tributyltin use has declined, environmental levels have decreased, and so too have the effects of this EDC on the wildlife living in these areas. However, organotins are still used as fungicides on numerous plants and as components in polyvinyl chloride plastic.

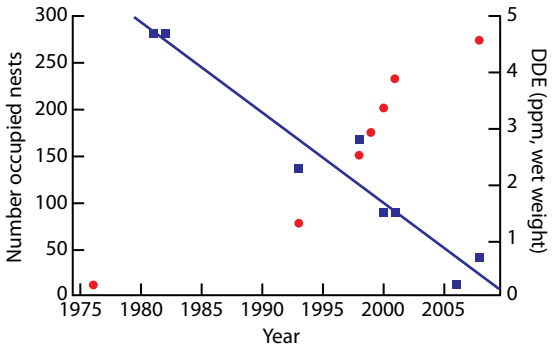


Figure 22. Wildlife populations affected by EDCs can recover after a ban of the chemical. This figure shows declining DDE ("blue square") concentrations (in parts per million wet weight) in osprey eggs in relation to the number of osprey nests occupied ("red dot") in Oregon, USA (based on data in Henny et al., 2010).

POPs such as PCBs and DDT were banned in many countries over 20 years ago due to their environmental persistence and toxicity. As a result, their levels in humans and wildlife have declined in recent decades. Bird populations exposed to high levels of DDT, and in particular to its persistent metabolite, DDE, in the 1950s through 1970s in North America and Europe are, since 1975, showing lower concentrations of DDT and DDE and clear signs of recovery (**Figure 22**). However, there are studies showing that current low levels of these persistent chemicals are still causing harm, because they or their breakdown products remain in the environment long after their use has been banned.

Lead is an important example of the cost of inaction in the face of toxicity data. Lead has been a known neurotoxicant since the Roman times; nonetheless, it was used in gasoline and paint around the world. The impact of lead on children is profound, because it causes irreversible damage to developing bone and brain tissues. The most damaging impact resulted from the use of lead in gasoline, which caused an estimated intelligence quotient (IQ) loss of five points in millions of children worldwide.

The ban on tetraethyl lead in gasoline occurred only after decades of inaction, when substitutes were available. Following the ban in the USA, lead levels in children fell dramatically, showing that the ban had a huge impact on improving human health (**Figure 23**).

While this is an example of success, the scientific data were present many years before the policies were changed and the chemical was banned. During that time, children's health continued to be harmed. So the question is, when are there sufficient data to act? Perhaps the answer is in making more use of the precautionary principle to ban or restrict chemicals in order to reduce exposure early, even when there are significant but incomplete data and before there is significant and long-lasting harm.

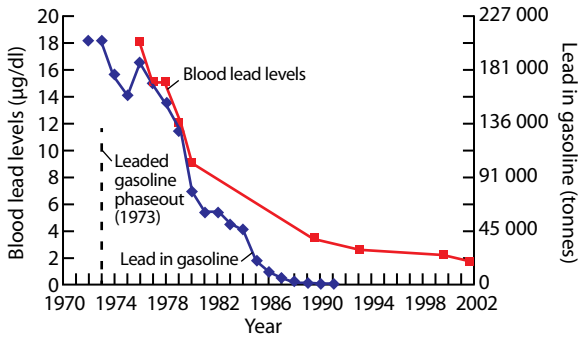


Figure 23. Ban on lead in gasoline and the impact of this decision on children's blood lead levels (based on data from the National Health and Nutrition Examination Survey in the USA).

13. Main conclusions and advances in knowledge since 2002

General aspects on endocrine disruption: Some endocrine disruptors can act directly on hormone receptors as hormone mimics or blockers. Others can act directly on any number of proteins that control the delivery of a hormone to its normal target cell or tissue. Further, the affinity of an endocrine disruptor to a hormone receptor is not equivalent to its potency, and the chemical potency on a hormone system is dependent upon many factors. Also, endocrine disruption represents a special form of toxicity, and this must be taken into consideration when interpreting the results of studies of EDCs or when designing studies to clarify the effects of EDCs and quantifying the risks to human and wildlife health.

Environmental chemicals can exert endocrine disrupting activity on more than just estrogen, androgen and thyroid hormone action. Some are known to interact with multiple hormone receptors simultaneously. Sensitivity to endocrine disruption is highest during tissue development; developmental effects will occur at lower doses than are required for effects in adults. Hence, testing for endocrine disruption must encompass the developmental period and include lifelong follow-up to assess latent effects.

Over the last 10 years, it has been established that endocrine disruptors can work together to produce additive effects, even when combined at low doses that individually do not produce observable effects. It has also become evident that endocrine disruptors may produce non-linear dose–response curves both in vitro and in vivo, by a variety of mechanisms.

Female reproductive health: Animal studies have shown that EDC exposures during early development can cause altered mammary gland and uterine development, accelerated or delayed puberty in females, disruption of fertility cycles, fibroids and endometriosis-like symptoms. These effects are similar to those seen in human populations, and it is reasonable to suspect that EDCs are adversely affecting human female reproductive health. Few studies have explored the role of EDCs and potential EDCs in causing female reproductive health disorders. Most of the available evidence comes from studies of adults rather than babies or children and often from exposures to POPs. Understanding of the contribution from more modern chemicals has only recently expanded.

There is much conflicting epidemiological evidence regarding the involvement of EDCs in premature puberty and breast development, menstrual cycles and adverse pregnancy outcomes (including preterm birth) in women. This is hardly surprising, considering the complexity of relating exposure measures to health outcomes relative to the timing and duration of exposures and including confounding factors such as maternal age and weight and the quality of prenatal care. There has been insufficient study of the relationship between EDC exposures and polycystic ovarian syndrome or fibroids in women. Limited data link phthalate exposures with increased fibroid prevalence. A number of studies have examined associations between exposure to chemicals and endometriosis, although most have measured exposure in adult life. PCBs, dioxins and phthalates are implicated, although studies are sometimes conflicting.

Historically high incidences of fibroids have also occurred in seal populations in the Baltic Sea and have been associated with exposure to contaminants (particularly PCBs and organochlorine pesticides). Recovery of these populations is now occurring, following a decline in the concentrations of these chemicals. More evidence now exists that reduced reproductive success in female birds, fish and gastropods is related to exposure to PCBs and dioxins. As exposure to these EDCs decreased, adverse reproductive effects in wild populations also decreased.

Male reproductive health: Occupational or accidental exposure of pregnant women to estrogen (DES) or to mixtures of EDCs that interfere with male hormone action (e.g. anti-androgenic pesticides) increases the risk of testicular non-descent (cryptorchidism) in their sons, causing reduced semen quality and increased risk of subfertility and testicular cancer in adult life. No associations have been found with individual chemicals, underlining the importance of including mixtures assessment in epidemiological and laboratory investigations.

Cryptorchidism is sometimes found together with penile malformations (hypospadias). Limited evidence suggests a slightly increased risk of hypospadias or of reduced semen quality associated with exposure to mixtures of endocrine disrupting pesticides. Limited evidence also

suggests links between maternal phthalate exposure and reduced anogenital distance (a proxy for reduced semen quality) in baby boys. For most chemicals, associations between fetal exposure and childhood or adult male reproductive health have not been studied. Few data sets contain measures of chemical exposures in pregnant women and of semen quality in their adult sons 20–40 years later.

Laboratory experiments with rats and epidemiological studies strongly suggest that the co-occurrence of cryptorchidism, hypospadias, testis germ cell cancer and impaired semen quality is the result of reduced androgen action during fetal development, causing testicular dysgenesis syndrome. Using the rat model, a large and convincing body of literature shows that a wide range of anti-androgenic and estrogenic EDCs can cause testicular dysgenesis syndrome in the laboratory rat. Chemicals testing positive in this model include phthalate plasticizers and a range of anti-androgenic fungicides and pesticides. Limited evidence also exists for the painkiller paracetamol. Effects of phthalates in the rat are not seen in the mouse or in human testis ex vivo, and for bisphenol A (BPA), the human testis model is more sensitive to toxic effects than the rat model. Better models of the human testis are needed for use in chemical testing.

With the exception of testicular germ cell cancers, which are logistically difficult to detect, symptoms of androgen deficiency and estrogen exposure also occur in a variety of wildlife species in both urban and rural environments and have been associated with exposure to chemicals in a limited number of species in some areas. The feminizing effects of estrogenic chemicals from sewage effluents on male fish was first reported in the 1990s and have now been seen in many countries and in several species of fish, indicating that this is a widespread phenomenon. Feminized (intersex) male fish have reduced sperm production and reduced reproductive success. The suite of effects seen in wildlife can be reproduced in laboratory studies in which experimental animals are exposed to estrogenic and anti-androgenic EDCs.

Sex ratios: EDC-related sex ratio imbalances, resulting in fewer male offspring in humans, do exist as shown for 2,3,7,8-tetrachlorodibenzo-p-dioxin and 1,2-dibromo-3-chloropropane, although the underlying mechanisms are unknown. Also, EDC-related sex ratio imbalances have been seen in wild fish and molluscs, and the effects of EDCs on sex ratios in some of these species are also supported by laboratory evidence.

Human fertility rates: Fertility rates are declining all over the world, particularly in industrialized countries. Although today we see stable, but ageing, human populations in Japan and Europe, we shall soon see significant reductions in their populations, as their fertility rates have been below replacement levels for 20–40 years. Contraception and changes in social family structures help explain these changes, although increasing reproductive health problems among men and women may also be important factors.

Population declines in wildlife: Wildlife species and populations continue to decline worldwide due to a number of factors, including overexploitation, loss of habitat, climate change and chemical contamination. Given our understanding of EDCs and their effects on the reproductive system, it is extremely likely that declines in the numbers of some wildlife populations (raptors, seals and snails) were because of the effects of chemicals (DDT, PCBs and tributyltin, respectively) on these species. The evidence for POPs as a cause of these population declines has increased now relative to 2002, due to increases in these populations following the restrictions on the use of these chemicals. EDCs in modern commerce with mechanisms of action similar to those of POPs are suspected to also be a factor contributing to declines seen in wildlife species today. Demonstrating a clear link between endocrine effects in individuals and population declines or other effects will always be challenging, however, because of the difficulty in isolating the effects of chemicals from the effects of other stressors and ecological factors. An endocrine mechanism for current wildlife declines is probable but not proven.

Thyroid health: Epidemiological evidence suggests that several groups of common contaminants, including PCBs, brominated flame retardants, phthalates, BPA and perfluorinated chemicals, are associated with reduced serum thyroid hormone levels in humans. Moreover, a much longer list of chemicals has caused a reduction in circulating levels of thyroid hormones or interfered directly with thyroid hormone action in experimental animals. Severe thyroid hormone deficiency causes severe brain damage, such that universal screening of thyroid hormone levels in serum occurs all over the world. Moderate (25%) or even transient insufficiency of thyroid hormones during pregnancy is also associated with reduced IQ, ADHD and even autism in children and with hypothyroid disorders in adults. Moreover, reduced serum thyroid hormone levels, although

still within population ranges classified as clinically "normal", have been identified as risk factors for increased serum cholesterol and elevated blood pressure and reduced bone density in postmenopausal women and so will be useful measures to investigate the relationship between chemical exposures and disease.

Not all studies will find exactly the same relationships between exposure and disease outcomes due to the difficulties in standardizing exposure measures and levels of hormones relative to the timing and duration of exposure. For thyroid hormones, levels are so variable between individuals that multiple measures in the same individual would be required to estimate a "set point" with a precision of 5%. This known variability should be incorporated into study designs. The issue is whether the correlations between contaminant exposure and various measures of endocrine function are consistent with effects on population health that are mediated by effects on hormone action. The complexity underlying the data is interpreted by some to indicate that there is no convincing evidence that chemicals can interfere with thyroid hormone action in humans. Considering that there is strong evidence linking thyroid hormone levels with adverse outcomes, particularly in children, precautionary approaches are necessary.

There is strong evidence to conclude that thyroid hormones play the same role in brain development in both animals and humans. Therefore, rodents are useful models for testing chemicals in order to protect human populations from additional exposures. The current set of validated test methods and human clinical measures, however, considers changes in thyroid hormone levels only and needs to be improved to encompass changes in thyroid hormone action. This means that there could be inconsistent relationships between exposure to thyroid disrupting chemicals and measures of thyroid function in humans, but very strong evidence in animals indicating that chemicals can interfere with thyroid hormone action. This is certainly true for PCBs.

Evidence of relationships between exposure to chemicals and thyroid hormone disruption in wildlife species has improved in the last decade, especially in relation to exposure to the flame retardant PBDEs and PCBs, but other chemicals have been inadequately studied. The strength of evidence supporting a role for EDCs in disrupting thyroid function in wildlife adds credence to the hypothesis that this could occur in humans.

Thyroid disruption is acknowledged to be poorly addressed by the chemical tests currently listed in the Organisation for Economic Co-operation and Development (OECD) conceptual framework. Genetic lines of mice are now widely available that could help clarify the mechanisms by which chemical exposures can interfere with thyroid hormone action.

Neurodevelopment: It is not widely appreciated that hormones play many critical roles in neurodevelopment, including the neuroendocrine circuits that control sex-specific behaviour and physiology, and therefore that EDCs could cause a series of behavioural conditions and psychiatric disorders that are evident in societies. Sufficient data indicate that in utero exposure to EDCs affects cognition in animal studies, and limited data indicate that sexually dimorphic behaviours are also affected. Although some test guidelines for developmental neurotoxicity have been developed, no chemical testing strategies currently require evaluation of the ability of chemicals to produce such effects.

There are sufficient data in human populations to conclude that high exposures to thyroid disrupting PCBs during fetal development (e.g. the children whose mothers ate contaminated fish from Lake Michigan or in the Yu-Cheng, or "oil disease", children born to mothers exposed to PCBs) or to potential EDCs, such as lead and mercury, are linked to general cognitive problems and alterations in sexual behaviour. Even relatively low exposures, however, are associated with reduced cognitive function. The most consistent observations are with impaired executive functioning, followed by processing speed, verbal ability and visual recognition and memory. ADHD is overrepresented in children whose mothers had low thyroxine levels in the first trimester of pregnancy and in populations with elevated exposure to organophosphate pesticides, still found in some populations. There is almost no information concerning the effects of mixtures of neuroendocrine disruptors, even though we know that they co-exist in human tissues. Data available suggest additive effects of different chemicals.

Studies of exposed wildlife provide important information on exposure levels, early and subclinical effects and the clinical neurotoxicity of EDCs, because the mechanisms, underlying effects and outcomes of exposure are often similar to those in humans. Data showing effects on growth, development and behaviour in wildlife exist for some PCBs and mercury, but are sparse or non-existent for other EDCs.

Hormone-related cancers: Despite a great deal of research, the causes of most hormonal cancers are a mystery. It is clear that hormones are required for the growth of cancerous tissues, but their involvement in the earlier stages of carcinogenesis, through perhaps epigenetic effects, is unclear. Studies with animals now show that exposure to hormones (synthetic or natural) or EDCs (e.g. PCBs, PBDEs, dioxins, some organochlorine pesticides, BPA) during early development of some endocrine glands (e.g. breast, endometrium, prostate) can alter their development, perhaps through effects on stem cells, with possible consequences for susceptibility to cancer. In some cases, cancer has been demonstrated in these animals. In the thyroid gland, the existence of stem cells has been hypothesized, but not demonstrated. Although various chemicals have been shown to cause thyroid cancer in animals, current understanding of thyroid cancer does not link it to an endocrine mechanism.

Many poorly designed and conflicting studies have arisen, until very recently, from lack of knowledge that exposures must consider mixtures and must be measured before the cancer appears, in fetal development, in many cases. This means that, despite growing evidence that hormones are risk factors for several endocrine cancers, few epidemiological studies have shown links with EDCs. For breast cancer, the most convincing evidence appears to come from associations with EDCs devoid of estrogenic activity, such as dioxins and furans, for which sufficient evidence exists. For endometrial and ovarian cancer, very few studies have been carried out, and those that exist are conflicting. For prostate cancer, sufficient evidence exists for an association with exposures to mixtures of pesticides in agriculture and in pesticide manufacturing and to cadmium and arsenic, whereas evidence is conflicting for an association with PCB and organochlorine exposures. Many of the pesticides are acetylcholinesterase inhibitors, which also interfere with metabolic conversion of hormones. Very many chemicals have not been investigated at all. For thyroid cancer, limited studies indicate higher rates in pesticide applicators, although some of these also stem from iodine deficiencies in these people.

Similar types of cancers of the endocrine organs, particularly reproductive organs, are also found in wildlife species (several species of marine mammals and invertebrates) and in domestic pets. In wildlife, endocrine tumours tend to be more common in animals living in polluted regions than in those inhabiting more pristine environments.

There are many deficiencies in regulatory testing methodologies for EDCs. Rodent strains developed for carcinogen testing were not developed as models for the demonstration of mammary cancer; an animal mammary carcinogen may be a human carcinogen, but not necessarily with the breast as a target organ. Other rat strains not routinely used for testing would be more suitable for testing, but have hitherto been used for only a handful of chemicals.

Adrenal disorders: Numerous chemicals, mainly POPs, potentially affecting adrenal structure and function have been described using in vitro assays, but no studies have investigated EDC associations with adrenal hormone secretion in humans. Few studies have been carried out with laboratory animals. The great majority of chemicals in commerce have not been tested.

Bone disorders: It is well established that bone is a target tissue for estrogens, which affect bone mineralization and maturation. Very little evidence, however, exists for effects of EDCs on these processes, except in cases of accidental high-exposure incidents with hexachlorobenzene , PCBs and polychlorinated dibenzofurans and in people eating contaminated fish from the Baltic Sea.

Metabolic disorders: The control of metabolism involves many components of the endocrine system, including the adipose tissues, brain, skeletal muscle, liver, pancreas, thyroid gland and gastrointestinal tract. There are now animal data showing that embryonic exposure to EDCs or potential EDCs (e.g. tributyltin, BPA, some organochlorine and organophosphate pesticides, lead, perfluorooctanoic acid, phthalates) leads to altered cholesterol metabolism, possible weight gain and type 2 diabetes in adulthood. There are no compelling animal data linking chemical exposures to type 1 diabetes, although some chemicals can affect the function of insulin-producing beta cells in the pancreas, including BPA, PCBs, dioxins, arsenic and some phthalates. Many of these chemicals are also immunotoxic in animal models, and so it is plausible that they could act via both immune and endocrine mechanisms to cause type 1 diabetes. Metabolic syndrome may also result from chemical exposures, although there has been little study of this.

Limited epidemiological data exist to support the notion that EDC exposure during pregnancy can affect weight gain in infants and children. Limited epidemiological data show that adult exposures to some EDCs (mainly POPs, arsenic and BPA) are associated with type 2 diabetes, but there are

no data for type 1 diabetes, there is insufficient evidence of endocrine mechanisms and there is insufficient study of this area in general.

Immune disorders: It is increasingly clear that EDCs likely play a role in the rise in immune-related disorders in both humans and wildlife. Many immune disorders have well-established ties to the endocrine system, such that disruption of select endocrine pathways may disturb the immune response, potentially causing allergies, endometriosis, bone disorders, autoimmune thyroid disease and immune cancers. This is because the immune and endocrine systems are intricately connected through cross-talk between certain hormonal receptors and immune signalling pathways. Sufficient data now support a role for the lipid X receptor (LXR) and the steroid and xenobiotic receptor (SXR) in regulating white blood cell proliferation, and there are data linking inflammation, immune dysfunction and immune cancers with EDCs.

Several studies with animals have demonstrated activation or repression of receptor signalling pathways involved in immune–endocrine interactions by organochlorine pesticides, PCBs, organotins, alkylphenols, phthalates, atrazine and BPA. Limited experimental and epidemiological evidence suggests that some PCBs, estrogens, atrazine and phthalates are developmental immunotoxicants, causing increased risk of inflammatory and autoimmune disorders. There are strong links, supported by animal studies, between phthalate exposure and the rising incidence of asthma. Endocrine mechanisms are highly plausible, but are not always proven or investigated. Together, these new insights stress a critical need to better understand how EDCs affect normal immune function and immune disorders and how windows of exposure may affect disease incidence (particularly for childhood respiratory diseases).

Human and wildlife exposures to EDCs: There is far more knowledge on EDC exposure today than there was 10 years ago. This applies to the diversity of chemicals being implicated as EDCs and exposure routes and levels in humans and wildlife. As examples, brominated flame retardants were mentioned only briefly and perfluorinated compounds not at all when the IPCS document on EDCs was prepared 10 years ago (IPCS, 2002). In addition to these, there are now many more EDCs being found in both humans and wildlife. The most relevant main messages regarding exposure to EDCs are summarized below.

Unlike 10 years ago, it is now better understood that humans and wildlife are exposed to far more EDCs than just POPs. EDCs are chemically diverse, are primarily man-made chemicals and are used in a wide range of materials and goods. EDCs are present in food, nature (wildlife) and human beings. They can also be formed as breakdown products from other anthropogenic chemicals in the environment and in humans, wildlife and plants. Humans and wildlife are exposed to multiple EDCs at the same time, and there is justifiable concern that different EDCs can act together and result in an increased risk of adverse effects on human and wildlife health. Exposures to EDCs occur during vulnerable periods of human and wildlife development—from fertilization through fetal development and through nursing of young offspring—which raises particular concern. Children can have higher exposures due to their hand-to-mouth activities and higher metabolic rate.

Right now, only a narrow spectrum of chemicals and a few classes of EDCs are measured, making up the "tip of the iceberg". More comprehensive assessments of human and wildlife exposures to diverse mixtures of EDCs are needed. It should be a global priority to develop the capacities to measure any potential EDCs. Ideally, an "exposome", or a highly detailed map of environmental exposures that might occur throughout a lifetime, should be developed. New sources of exposure to EDCs, in addition to food, have been identified and include indoor environments and electronics recycling and dumpsites (the latter being issues of particular concern for developing countries and countries with economics in transition). Not all sources of exposure to EDCs are known because of the lack of chemical constituent declarations for materials and goods.

There is global transport of EDCs through natural processes (ocean and air currents) as well as through commerce, leading to worldwide exposure of humans and wildlife to EDCs. Spatial and temporal monitoring is critical for understanding trends and levels of exposure. This monitoring should include tissues from both humans and wildlife (representing a range of species) as well as water or other environmental compartments to capture the less persistent EDCs. Levels in humans and wildlife are related to how much a chemical is used. Bans on several POPs have led to declines in environmental levels and human body burdens. In contrast, there are increasing levels of some newer EDCs, such as perfluorinated alkyl compounds and replacements for banned brominated flame retardants.

14. Concluding remarks

EDCs have the capacity to interfere with tissue and organ development and function, and therefore they may alter susceptibility to different types of diseases throughout life. This is a global threat that needs to be resolved.

Progress

We are starting to understand that a large number of non-communicable diseases have their origin during development and that environmental factors interact with our genetic background to increase susceptibility to a variety of diseases and disorders. It is also clear that one of the important environmental risk factors for endocrine disease is exposure to EDCs during development. It is also clear from human studies that we are exposed to perhaps hundreds of environmental chemicals at any one time. It is now virtually impossible to examine an unexposed population around the globe. Trends indicate an increasing burden of certain endocrine diseases across the globe in which EDCs are likely playing an important role, and future generations may also be affected.

The advances in our understanding of EDCs have been based mainly on information derived from studies in developed regions. As in 2002, there is still a major lack of data from large parts of the world, in particular from Africa, Asia and Central and South America.

Future needs

Better information on how and when EDCs act is needed to reduce exposures during development and prevent disease from occurring. A clear example of the success of primary prevention through exposure control is lead. We have identified the following needs to take advantage of current knowledge to improve human and wildlife health by prevention of environmentally induced diseases.

A. Strengthening knowledge of EDCs: It is critical to move beyond the piecemeal, one chemical at a time, one disease at a time, one dose approach currently used by scientists studying animal models, humans or wildlife. Understanding the effects of the mixtures of chemicals to which humans and wildlife are exposed is increasingly important. Assessment of EDC action by scientists needs to take into account the characteristics of the endocrine system that are being disrupted, including tissue specificity and sensitive windows of exposure across the lifespan. While there are different perspectives on the importance of low-dose effects and non-monotonic dose–response curves for EDCs, this issue is important in determining whether current testing protocols are sufficient to identify EDCs. Interdisciplinary efforts that combine knowledge from wildlife, experimental animal and human studies are needed to provide a more holistic approach for identifying the chemicals that are responsible for the increased incidence of endocrine-related disease and dysfunction. The known EDCs may not be representative of the full range of relevant molecular structures and properties due to a far too narrow focus on halogenated chemicals for many exposure assessments and testing for endocrine disrupting effects. Thus, research is needed to identify other possible EDCs. Endocrine disruption is no longer limited to estrogenic, androgenic and thyroid pathways. Chemicals also interfere with metabolism, fat storage, bone development and the immune system, and this suggests that all endocrine systems can and will be affected by EDCs. Together, these new insights stress a critical need to acquire a better understanding of the endocrine system to determine how EDCs affect normal endocrine function, how windows of exposure may affect disease incidence (particularly for childhood respiratory diseases) and how these effects may be passed on to generations to come.

Furthermore, new approaches are needed to examine the effects of mixtures of endocrine disruptors on disease susceptibility and etiology, as examination of one endocrine disruptor at a time is likely to underestimate the combined risk from simultaneous exposure to multiple endocrine disruptors. Assessment of human health effects due to EDCs needs to include the effects of exposure to chemical mixtures on a single disease as well as the effects of exposure to a single chemical on multiple diseases. Since human studies, while important, cannot show cause and effect, it is critical to develop cause and effect data in animals to support the studies on humans.

B. Improved testing for EDCs: Validated screening and testing systems have been developed by a number of governments, and it requires considerable time and effort to ensure that these systems function properly. These systems include both in vitro and in vivo end-points and various species, including fish, amphibians and mammals. New approaches are also being explored whereby large batteries of high-throughput in vitro tests are being investigated for their ability to predict toxicity, the results of which may be used in hazard identification and potentially risk assessment. These new approaches are important as one considers the number of chemicals for which there is no information, and these high-throughput assays may provide important, albeit incomplete, information. An additional challenge to moving forward is that EDC research over the past decade has

revealed the complex interactions of some chemicals with endocrine systems, which may escape detection in current validated test systems. Finally, it will be important to develop weight-of-evidence approaches that allow effective consideration of research from all levels—from in vitro mechanistic data to human epidemiological data.

C. Reducing exposures and thereby vulnerability to disease: It is imperative that we know the nature of EDCs to which humans and wildlife are exposed, together with information about their concentrations in blood, placenta, amniotic fluid and other tissues, across lifespans, sexes, ethnicities (or species of wildlife) and regions. Many information gaps currently exist with regard to what is found in human and wildlife tissues, more so for developing countries and countries with economies in transition and for chemicals that are less bioaccumulative in the body. Long-term records to help us understand changes in exposures exist only for POPs and only for a few countries.

In addition, there is a need to continue expanding the list of chemicals currently examined to include those contained in materials and goods as well as chemical by-products; it is impossible to assess exposure without knowing the chemicals to target. The comprehensive measurement of all exposure events during a lifetime is needed, as opposed to biomonitoring at specific time points, and this requires longitudinal sampling, particularly during critical life stages, such as fetal development, early childhood and the reproductive years.

Wildlife and humans are exposed to a wide variety of EDCs that differ greatly in their physical and chemical properties. Further, these compounds are generally present at trace concentrations and in complex matrices requiring highly selective and sensitive analytical methods for their measurement. The wide range of different compound classes requires a variety of analytical approaches and techniques, making it challenging to understand all of the different chemicals in the environment and in human and wildlife tissues. There is a growing need to develop new analytical techniques and approaches to prioritize the assessment of EDCs. There is global transport of EDCs through natural processes (ocean and air currents) as well as commerce, leading to worldwide exposures. New sources of exposure to EDCs, in addition to food, have been identified and include indoor environments and electronics recycling and dumpsites (of particular concern in developing countries and countries with economies in transition). The sources and routes of exposure to EDCs need to be further investigated.

D. Identifying endocrine active chemicals: Identifying chemicals with endocrine disrupting potential among all of the chemicals used and released worldwide is a major challenge, and it is likely that we are currently assessing only the "tip of the iceberg". It is possible to trace high production volume chemicals, but that is not the case for the numerous additives and process chemicals. Adding greatly to the complexity, and to the number of chemicals in our environment, are the unknown or unintended by-products that are formed during chemical manufacturing, during combustion processes and via environmental transformations. While the active ingredients in pharmaceuticals and pesticides have to be documented on the final product, this is not the case for chemicals in articles, materials and goods. Personal hygiene products and cosmetics require declarations of the ingredients, and the number of chemicals applied in this sphere of uses counts in the thousands. Many sources of EDCs are not known because of a lack of chemical constituent declarations in products, materials and goods. We need to know where the exposures are coming from.

E. Creating enabling environments for scientific advances, innovation and disease prevention: Exposure to EDCs and their effects on human and wildlife health are a global problem that will require global solutions. More programmes are needed that foster collaboration and data sharing among scientists and between governmental agencies and countries. To protect human health from the combined effects of exposures to EDCs, poor nutrition and poor living conditions, there is a need to develop programmes and collaborations among developed and developing countries and those in economic transition. There is also a need to stimulate new adaptive approaches that break down institutional and traditional scientific barriers and stimulate interdisciplinary and multidisciplinary team science.

F. Methods for evaluating evidence: There is currently no widely agreed system for evaluating the strength of evidence of associations between exposures to chemicals (including EDCs) and adverse health outcomes. A transparent methodology is also missing. The need for developing better approaches for evaluating the strength of evidence, together with improved methods of risk assessment, is widely recognized. Methods for synthesizing the science into evidence-based decisions have been developed and validated in clinical arenas. However, due to differences between environmental and clinical health sciences, the evidence base and decision context of these methods are not applicable to exposures to environmental contaminants, including EDCs. To meet this challenge, it will be necessary to exploit new methodological approaches. It is essential to evaluate associations between EDC exposures and health outcomes by further developing methods for which proof of concept is currently under development.

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Endocrine Disrupting Chemicals have many sources

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An Exploratory Study of Air Quality near Natural Gas Operations

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Relevant abbreviations and definitions:

COGCC	Colorado Oil and Gas Conservation Commission
Mcf	thousand cubic feet
ng/m^3	nanograms per cubic meter
NMHCs	non-methane hydrocarbons
PAHs	polycyclic aromatic hydrocarbons
ppbc	parts per billion carbon
ppbv	parts per billion by volume
pptv	parts per trillion by volume
$\mu g/m^3$	micrograms per cubic meter
µg/ml	micrograms per milliliter
VOCs	volatile organic compounds

ABSTRACT

This exploratory study was designed to assess air quality in a rural western Colorado area where residences and gas wells co-exist. Sampling was conducted before, during, and after drilling and hydraulic fracturing of a new natural gas well pad. Weekly air sampling for 1 year revealed that the number of non-methane hydrocarbons (NMHCs) and their concentrations were highest during the initial drilling phase and did not increase during hydraulic fracturing in this closed-loop system. Methylene chloride, a toxic solvent not reported in products used in drilling or hydraulic fracturing, was detected 73% of the time; several times in high concentrations. A literature search of the health effects of the NMHCs revealed that many had multiple health effects, including 30 that affect the endocrine system, which is susceptible to chemical impacts at very low concentrations, far less than government safety standards. Selected polycyclic aromatic hydrocarbons (PAHs) were at concentrations greater than those at which prenatally exposed children in urban studies had lower developmental and IQ scores. The human and environmental health impacts of the NMHCs, which are ozone precursors, should be examined further given that the natural gas industry is now operating in close proximity to human residences and public lands.

Key Words: drilling, endocrine disruptors, hydraulic fracturing, natural gas, non-methane hydrocarbons, PAHs, VOCs.

INTRODUCTION

Over the past 25 years the U.S. Environmental Protection Agency (USEPA) has supported research on ozone, particulate matter, and VOCs derived from the combustion of gasoline and diesel fuel by mobile and stationary sources. Air quality monitoring has focused primarily on large urban and industrialized areas in and around heavily populated regions across the U.S. and along chemical factory fence lines. Quantitative results dating back several decades are available from studies designed to test detection methodologies and to detect the quantity of selected VOC compounds in large urban areas or specific cities (Baker *et al.* 2008; Mohamed *et al.* 2002; Seila *et al.* 1989). This kind of air sampling has typically been done in regions of ozone non-compliance to determine the source of the precursors to ozone, providing guidance for regulating the source. Studies of urban air have also documented the damage these compounds cause to human health (Brunekreef *et al.* 2009; Chahine *et al.* 2007; Crüts *et al.* 2008; Dejmek *et al.* 2000; Green *et al.* 2009; Koren *et al.* 1989; Perera *et al.* 1999).

In the past two decades, natural gas development and production in the U.S. has increased rapidly by tapping into domestic resources. Natural gas wells are now being drilled in close proximity to urban and rural communities, and across broad expanses of public lands. Potential sources of air pollution from natural gas operations include volatile chemicals introduced during drilling and hydraulic fracturing (in which fluids are injected under high pressure to fracture the underlying formation that holds the gas), combustion byproducts from mobile and stationary equipment, chemicals used during maintenance of the well pad and equipment, and numerous NMHCs that surface with the raw natural gas. The USEPA estimates that on average the mass composition of unprocessed natural gas is 78.3% methane, 17.8% NMHCs, 1.8% nitrogen, 1.5% carbon dioxide, 0.5% hydrogen sulfide, and 0.1% water (Skone *et al.* 2011; USEPA 2011).

Two independent air sampling studies conducted near natural gas fields in Colorado have recently been published. McKenzie *et al.* (2012) measured air quality around the perimeter of natural gas wells from a stationary site among rural residences and ranches, assessing several NMHCs for the purpose of risk assessment. Petron *et al.* (2012) took a regional approach using data collected over 3 years by both fixed and mobile sampling equipment looking for sources and mixing ratios of methane and benzene and several other NMHCs. The authors identified an

alkane signature as evidence of oil and gas activity. Both studies indicate a need for better air monitoring and research on air quality near natural gas operations.

The present study was designed to explore the presence of volatile chemicals, many of which are associated with the production of natural gas, in a rural natural gas production area for 1 year. The sampling period spanned the time before, during, and after development of a natural gas well pad. Development included drilling, hydraulic fracturing, and production operations. To our knowledge, no study of this kind has been published to date.

PROJECT DESIGN

Baseline and weekly air samples were collected between July, 2010, and October, 2011, from a fixed sampling station near a well pad on which 16 vertical (directional) gas wells had been drilled, hydraulically fractured and put into production during the course of the study. Air sample data are presented along with a timeline of events on the well pad, including drilling, fracturing and production dates acquired from the website of the Colorado Oil and Gas Conservation Commission (COGCC). The COGCC serves as the primary government resource for the public regarding oil and gas development in Colorado and maintains a publicly available online information system as part of its oil and gas regulatory processes (COGCC 2012a).

Sampling Site

Site selection was dictated by our ability to set up a permanent sampling station with access to electricity near a well pad about to be developed. In July, 2010, a permanent air sampling location was selected in Garfield County, Colorado, at approximately 5,850 feet (1783 m) elevation and 0.7 miles (1.1 km) from the well pad of interest. The site was located at a rural residence in semi-arid terrain surrounded by pinyon, juniper, sagebrush, and native grasses. One major highway (I-70) runs through the area, approximately 1.1 miles (1.8 km) north of the sampling site. According to the COGCC (2012a), there were 130 wells producing natural gas within 1 mile (1.6 km) of the sampling site at the time of the study. In addition, two other well pads were developed using vertical drilling within 1 mile (1.6 km) of the sampling site after development of the well pad of interest, and within the timeframe of the study.

Natural Gas Well Pad

The vertical well pad of interest penetrated the Williams Fork Formation of the Mesa Verde Group at a total depth of approximately 8,300 feet (2530 km) in tight sands (FracFocus 2012). The land for the well pad was cleared of vegetation and leveled and service roads were constructed in the spring of 2010.

According to the COGCC website, drilling of the first of 16 wells started on October 22, 2010, and the last well was started on March 16, 2011. Hydraulic fracturing of the first four wells began on January 4, 2011. Fracturing reportedly began on another five wells on February15, 2011 (not including the seventh drilled well, which was not fractured until April 20th). Between April 14 and 16, 2011, six more wells were fractured. Volumes of hydraulic fracturing fluids ranged between 1.1 and 2.3 million gallons (4.2 and 8.7 million liters) per well (FracFocus 2012). Wells typically went into production within 5 days of being fractured.

According to the COGCC, the well pad was located in a sensitive area with regard to wildlife habitat and water resources, and was in close proximity to surface and domestic water wells (COGCC 2010). This required the operator to abide by a variety of requirements and best management practices designed to minimize impacts. For example, a closed loop drilling system was used that requires drilling fluids to be captured in tanks instead of separated from the cuttings and held in an open pit. A closed loop system was also used to pipe fracturing fluids to the pad and immediately capture the flow back fluids and pipe them to another facility for treatment.

METHODS

A baseline air sample for VOCs was collected July 17, 2010. A complete set of baseline samples was taken on October 19, 2010. Weekly sampling commenced beginning November 2, 2010 through October 11, 2011. Samples were collected on all dates except for December 28, 2010 because the lab was closed for Christmas. Samples were collected every 7 days and shipped by a trained technician according to standard operating procedure for each instrument (AAC 2012a; SKC Inc. 2001; Tisch Environmental, Inc.). The 24-hour samples were taken weekly from noon Monday to noon Tuesday, and the 4-hour samples were taken from 10:00–2:00 on Tuesdays.

Samples were sent to two USEPA certified laboratories using chain of custody procedures to assure proper handling of the samples from the technician to the lab. VOCs were

sampled over a 4-hour period using a Six-Liter Summa Canister. Lab analyses were conducted to test for the following VOCs: 56 speciated C2-C12 hydrocarbons using USEPA Method TO-12/USEPA PAMS Protocol (Photochemical Assessment Monitoring Stations, using gas chromatography/flame ionization detection); methane, using USEPA Method 18 (to detect fixed gases by gas chromatography/flame ionization detection/ thermal conductivity); and 68 target VOCs using USEPA Method TO-15 (to detect VOCs using gas chromatography/mass spectrometry).

PAHs were sampled over 24 hours using a Filter/PUF (Polyurethane) combination. Sixteen PAHs were tested using USEPA Method TO-13A (to detect a select group of PAHs with gas chromatography/mass spectrometry). Carbonyls were sampled over a 4-hour period using a DNPH (2-4 dinitrophenylhydrazine) coated Silica Gel Cartridge, and 12 carbonyls were tested using USEPA Method TO-11A (to detect aldehydes and ketones using high-pressure liquid chromatography with a UV detector).

The 4-hour sampling of VOCs and carbonyls was extended to 6 hours, generally from 9:00 am to 3:00 pm with a few samples taken from 10:00 am to 4:00 pm, beginning April 5, 2011. This change was made upon approval by the lab, in order to accommodate the schedule of the sampling technician. Additionally, due to the high cost of the PAH assay, and the findings of PAH concentrations three orders of magnitude lower than the other NMHCs, PAH sampling was discontinued when drilling on the well pad of interest ended (after March 29, 2011).

The samples from the Summa Canisters and the DNPH Cartridges were analyzed by Atmospheric Analysis & Consulting, Inc., Ventura, CA, a National Environmental Laboratory Accreditation Conference approved air quality analytical laboratory. The Filter/PUF analyses were conducted by American Environmental Testing Laboratory, Inc., Burbank, CA. Quality control data including duplicate and spike recoveries was provided in all laboratory reports. Chemicals analyzed in more than one assay are reported as follows: for hexane, toluene, heptane, benzene, and cyclohexane, TO-12 values were used instead of TO-15; and for acetone, TO-15 values were used instead of TO-11A.

All test values were reported by the laboratories without problems, with the exception of one Summa Canister sample with a pressure problem, and six DNPH Cartridge samples—two with equipment problems and four with visible water contamination. The results of all tests with

reported problems were omitted from analysis, resulting in 48 samples reported for VOCs, 21 for PAHs, and 43 for carbonyls.

Analyses

Means, ranges, and standard deviations are presented for all chemicals detected at least once. Means were calculated by summing the values for each chemical and dividing by the number of detects for that chemical. Mean, standard deviation, and range values are reported in parts-per-billion (ppbv) or parts-per-trillion (pptv) volume. Conversions from parts-per-billion carbon and ng/m^3 were conducted as necessary to arrive at this common reporting unit (AAC 2012b). Sample detection values greater than one standard deviation above the mean for each chemical were defined as spikes. Because of the exploratory nature of the study and the relatively small data set, values for non-detects were not imputed, no data transformations were performed, and statistical tests of significance were not conducted.

RESULTS

Chemicals that were tested but never detected (non-detects) are presented in Table 1, along with the Method Reporting Limit (MRL). Shown in Table 2 are basic descriptive statistics for all the VOCs and carbonyls detected at least once during the sampling period, in order of the percent of detections. Among the VOCs, four chemicals were detected in every sample: methane, ethane, propane, and toluene. Chemicals with the highest mean values across the sampling period include (in order of mean value): methane, methylene chloride, ethane, methanol, ethanol, acetone, and propane. Regarding the carbonyls, formaldehyde and acetaldehyde were detected in every sample. The highest values were for crotonaldehyde and formaldehyde. Also shown in Table 2 are the numbers of times each chemical spiked during the sampling period.

Shown in Table 3 are the results for the PAHs, which were sampled from November 2, 2010, to March 29, 2011. Naphthalene was the only PAH detected in every sample and it was also found at the highest concentration among the PAHs detected.

Related Events on the Well Pad

Pertinent events on the pad (*e.g.*, start dates for drilling and hydraulic fracturing) are shown in Figure 1. Dates are included for the well pad of interest (Pad #1) as well as for the two

pads that were developed during the latter half of sampling (Pads #2 and #3). The percent and number of chemicals detected on each date of sampling is also shown in Figure 1. Percents were calculated by dividing the number of chemicals detected on a particular date by the total number of chemicals analyzed on that day, not including chemicals that were never detected during the study. The number and percent of detections were generally higher during development of Pad #1 than Pads #2-3. The most chemical detections occurred during the first four months of drilling, at a time when only one fracturing event occurred, which did not change the pattern of detections.

The number of spikes on each date of sampling is shown in Figure 2, presented separately by type of compound (VOC, PAH, carbonyl). By far the most spikes occurred during drilling of Pad #1, particularly between mid-December and mid-January. The carbonyls spiked on and around March 15, 2011. There were also spikes beginning in July, 2011, when drilling of Pad #3 began.

DISCUSSION

The data in this study show that air sampling near natural gas operations reveals numerous chemicals in the air, many associated with natural gas operations. Some of the highest concentrations in the study were from methane, ethane, propane, and other alkanes that have been sourced to natural gas operations (Baker *et al.* 2008; Gilman *et al.* 2012). In contrast we found very low levels of chemicals such as ethene and other alkenes that are more likely to come from urban road-based pollution (Baker *et al.* 2008; Gilman *et al.* 2012). Acetylene, which is only formed from combustion, was found at low concentrations and in only four samples. Isoprene, which arises primarily from vegetation, was only detected in one sample throughout the study, attesting to the semi-arid landscape of the sampling site (Baker *et al.* 2008; Jobson *et al.* 1994). The chemicals reported in this exploratory study cannot, however, be causally connected to natural gas operations.

Air Resource Specialists, Inc. provides quarterly weather reports from Parachute, Colorado, which is 7.4 miles (11.9 km) southwest of the sampling site (Air Resource Specialists, Inc. 2011a, 2011b, 2011c, 2011d). Wind rose data show that the predominant wind directions throughout the year are from the NE and SW, which is aligned with the topography of the valley along the Colorado River Corridor. During all four quarters of the study year the wind blew from

the ESE (from the well pad toward the sampling site) 2–3% of the time, independent of the time of year. There was no correlation between detected emissions (which varied by quarter and were highest in the winter) and wind direction.

Calm winds, however, (wind under 1 mph) were greatest during times when detections were highest. For example, in the fourth quarter of 2010, winds were calm 10.9% of the time, and in the first quarter of 2011 they were calm 8.1% of the time. During the second and third quarters of 2011, when air sampling detections were lower, calm winds were reported 3.5% and 1.8% of the time, respectively. Because of the rugged topography of the area under study it is subject to air inversions, particularly in winter, which trap air at ground level and tend to increase air pollution from local sources (Sexton and Westberg *et al.* 1984). The phenomena of air inversions may explain the higher readings during December and January than in other months.

There was a great deal of variability across sampling dates in the numbers and concentrations of chemicals detected. Notably, the highest percentage of detections occurred during the initial drilling phase, prior to hydraulic fracturing on the well pad. This is not surprising, considering the numerous opportunities for release of NMHCs during drilling. On a typical well pad, when the raw natural gas surfaces it is piped to a glycol dehydrator (heater treater) on the pad where it is heated to evaporate off the water, which then condenses and is stored on the pad in tanks marked "produced water". During the heating process numerous NMHCs are vented while others are piped to a condensate tank on the pad. NMHCs also escape when the glycol in the dehydrator is being regenerated. Transferring of fluids from the produced water and condensate tanks to tanker trucks is another opportunity for the release of NMHCs. Next, the gas goes to a compressor station where is prepped and sent on to a processing plant where the BTEXs (benzene, toluene, ethylbenzene, and xylene), and other NMHCs, some of which are liquids at low temperatures are removed. A number of volatile chemicals, such as benzene, toluene, xylenes and others, have economic value and are captured and used to make diverse products such as plastics, glass, construction material, pesticides, detergents, cosmetics, and pharmaceuticals, and in the U.S. they are added to gasoline.

For well pad #1 in the present study, after all the wells were completed and hooked into the national supply line, according to the COGCC the well pad produced 487,652 Mcf (thousand cubic feet) of raw natural gas during June, 2011 (COGCC 2012b). Using the USEPA estimate of

17.8% NMHCs, that calculates to 2,893 Mcf per day of NMHCs potentially released into the air while the pad is producing, although not all the NMHCs are released on-site.

Methylene chloride stood out due to the extremely high concentrations in some of the samples, including one reading of 1730 ppbv, and three other readings more than 563 ppbv (the cutoff value for spikes) during the period of well development. In contrast, after activity on the pad came to an end and the wells went into production, the highest level of methylene chloride detected was 10.6 ppb. Methylene chloride is not a natural component in raw gas, and is predominantly used as a solvent (USEPA 2000). As far as we are aware, it is not a component in drilling or fracturing fluids. It does not appear on two extensive lists of more than 750 chemicals that companies admit they use during either operation (Colborn *et al.* 2011; US House of Representatives Committee on Energy and Commerce Minority Staff 2011) and it does not appear on the voluntary fracturing chemical disclosure registry (FracFocus 2012) for the well pad of interest in this study. However, residents and gas field workers have reported that methylene chloride is stored on well pads for cleaning purposes. Raw gas in the region under study also contains commercially valuable levels of a mixture of alkanes referred to as paraffin wax that becomes solid at ambient temperatures. As the raw gas escapes on the pad, this slippery material could build up on equipment, requiring cleaning. Given that methylene chloride was found in such high concentrations in air samples in the present study, its source and potential exposure scenarios should be explored with respect to exposure of individuals working on the pads and living nearby.

Regarding the PAHs, although concentrations found in this study appear low, they may have clinical significance. Several studies have been published by the Columbia Center for Children's Environmental Health in which pregnant women in urban settings wore personal air monitors that measured their level of exposure to eight PAHs (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene). In 2006, Perera *et al.* demonstrated that among children in New York City, those who were prenatally exposed to eight PAHs with a summed concentration greater than 4.16 ng/m^3 had lower mental development scores at age three. In 2009, Perera *et al.* reported lower IQ scores among 5-year olds with prenatal exposure greater than 2.26 ng/m^3. In a similar study in Krakow, Poland, Edwards *et al.* (2010) found decreased IQ scores among 5-year olds prenatally exposed to PAHs greater than 17.96 ng/m^3. In the present

study, the summed composite of the same eight PAHs was 15.5 ng/m^3. There are many sources of variability when comparing personal air monitoring and ambient air sampling results. For example, not all eight PAHs summed above were detected in every one of our samples. Nonetheless, these findings suggest that the concentrations of PAHs in rural neighborhoods near natural gas operations deserve further investigation, regardless of the source.

The concentrations of the carbonyls were lowest during the time when the VOCs and PAHs were spiking, but spiked later when the other chemicals did not. Many carbonyls, such as formaldehyde and acetaldehyde, are formed from the reaction of VOCs with nitrogen oxide and sunlight, and thus have peak seasons, which may have accounted for the spikes (Ho *et al.* 2002; National Research Council 1981). Carbonyls are also used as solvents and are associated with diesel emissions (ATSDR 1999; Mitran *et al.* 1997). It is possible that solvents were needed following the accident that occurred when a drilling contractor was removing drill cuttings from the mud tanks (COGCC 2011), which coincided with the time the carbonyls spiked in March.

In order to identify potential hazards associated with the chemicals detected during development of the well pad of interest, a rigorous literature search was conducted. Thirty-five chemicals were found to affect the brain/nervous system, 33 the liver/metabolism, and 30 the endocrine system, which includes reproductive and developmental effects. The categories with the next highest numbers of effects were the immune system (28), cardiovascular/blood (27), and the sensory and respiratory systems (25 each). Eight chemicals had health effects in all 12 categories. There were also several chemicals for which no health effect data could be found. The categories of health effects for each chemical are presented in Table 4, which is supported by Supplemental Material available from the authors that contains a complete list of 400 references. It should be mentioned that laboratory studies typically measure exposure to one chemical at a time, while real-life conditions entail exposure to several volatile chemicals at once, with interactions that cannot be predicted.

The health effects found in the literature are relevant as indicators of potential hazards associated with the chemicals detected in the air samples. They do not address the issue of exposure. The concentrations at which these chemicals were detected in the air are far less than U.S. government safety standards such as NIOSH Recommended Exposure Limits and OSHA Permissible Exposure Limits (NIOSH 1992; OSHA 1993). However, government standards are typically based on the exposure of a grown man encountering relatively high concentrations of a

chemical over a brief time period, for example, during occupational exposure. Consequently, such standards may not apply to exposure scenarios faced by individuals (including pregnant women, children, and the elderly) experiencing chronic, sporadic, low-level exposure, 24 hours a day 7 days a week in natural gas neighborhoods. Safety standards also do not account for the kinds of effects found from low-level exposure to endocrine disrupting chemicals (Vandenberg *et al.* 2012), which can be particularly harmful during prenatal development and childhood.

Lessons can be learned from the results of this simple exploratory investigation into air quality in a rural neighborhood interspersed with natural gas operations. In retrospect, we regret not having continued sampling PAHs throughout the entire year. It was not until we began searching the literature for health effects of the chemicals that we discovered the developmental effects of extremely low levels of PAHs. In addition, our study would have benefited from more baseline samples. Unfortunately, there was no way to know exactly when drilling would start and we were only alerted when the drill rig was being installed. If we were to sample again, we would rotate sampling every six days and at varied times around the clock. Most importantly, we would record meteorological data on-site throughout each sampling period. In rural mountainous areas, where local topography varies greatly, public sources of weather data may not be applicable for air quality research.

While natural gas development and production continues to spread across the land it is moving closer to homes, schools, and places of business. At the same time more and more raw gas will be released into the atmosphere on a steady, daily basis. In order to determine how to reduce human exposure for both those who work on the well pads and those living nearby, systematic air quality monitoring of natural gas operations must become a regular part of permitting requirements. It is apparent from what is presented in this paper that the NMHCs need far more attention not only because of their potential immediate and long term chronic health effects, but also for their secondary indirect health and environmental impacts as precursors to ozone.

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Table 1. Chemicals not detected in air samples in western Colorado from July, 2010 to October, 2011.

Chemical	CAS#	Reporting limit[a]
1,1,1-trichloroethane	71-55-6	0.5 ppbv
1,1,2,2-tetrachloroethane	79-34-5	0.5 ppbv
1,1,2-trichloro-1,2,2-trifluoroethane	76-13-1	0.5 ppbv
1,1,2-trichloroethane	79-00-5	0.5 ppbv
1,1-dichloroethane	75-34-3	0.5 ppbv
1,1-dichloroethene	75-35-4	1 ppbv
1,2,3-trimethylbenzene	526-73-8	1 ppbv
1,2,4-trichlorobenzene	120-82-1	0.5 ppbv
1,2-dibromoethane	106-93-4	0.5 ppbv
1,2-dichloro-1,1,2,2-tetrafluoroethane	76-14-2	0.5 ppbv
1,2-dichlorobenzene	95-50-1	0.5 ppbv
1,2-dichloroethane	107-06-2	0.5 ppbv
1,2-dichloropropane	78-87-5	0.5 ppbv
1,3,5-trimethylbenzene	108-67-8	1 ppbc
1,3-butadiene	106-99-0	0.5 ppbv
1,3-dichlorobenzene	541-73-1	0.5 ppbv
1,4-dichlorobenzene	106-46-7	0.5 ppbv
1,4-dioxane	123-91-1	0.5 ppbv
1-butene	106-98-9	1 ppbc
1-hexene	592-41-6	1 ppbc
1-pentene	109-67-1	1 ppbc
2,2,4-trimethylpentane	540-84-1	1 ppbc
2,2-dimethylbutane	75-83-2	1 ppbc
2,3,4-trimethylpentane	565-75-3	1 ppbc
2,3-dimethylpentane	565-59-3	1 ppbc
2,4-dimethylpentane	108-08-7	1 ppbc
2-hexanone	591-78-6	0.5 ppbv
4-ethyltoluene	622-96-8	0.5 ppbv
acenaphthene	83-32-9	2 ng/m^3 (pql)
acrolein	107-02-8	0.025 µg/ml
acrylonitrile	107-13-1	1 ppbv
allyl chloride	107-05-1	0.5 ppbv
anthracene	120-12-7	2 ng/m^3 (pql)
benzyl chloride	100-44-7	0.5 ppbv
bromodichloromethane	75-27-4	0.5 ppbv
bromoform	75-25-2	0.5 ppbv
bromomethane	74-83-9	0.5 ppbv
carbon disulfide	75-15-0	0.5 ppbv
carbon tetrachloride	56-23-5	0.5 ppbv
chlorobenzene	108-90-7	0.5 ppbv
chlorodifluoromethane	75-45-6	0.5 ppbv

Table 1. (cont.)

Chemical	CAS#	Reporting limit[a]
chloroethane	75-00-3	0.5 ppbv
chloroform	67-66-3	0.5 ppbv
chloromethane	74-87-3	0.5 ppbv
cis-1,2-dichloroethylene	156-59-2	0.5 ppbv
cis-1,3-dichloropropene	10061-01-5	0.5 ppbv
cis-2-butene	590-18-1	1 ppbc
cis-2-pentene	627-20-3	1 ppbc
dibromochloromethane	124-48-1	0.5 ppbv
dichlorodifluoromethane	75-71-8	0.5 ppbv
dichlorofluoromethane	75-43-4	0.5 ppbv
ethyl acetate	141-78-6	0.5 ppbv
fluoranthene	206-44-0	2 ng/m^3 (pql)
hexachlorobutadiene	87-68-3	0.5 ppbv
isooctane	540-84-1	0.5 ppbv
isopropyl alcohol	67-63-0	2 ppbv
m-diethylbenzene	141-93-5	1 ppbc
methyl isobutyl ketone (MIBK)	108-10-1	0.5 ppbv
methyl tert-butyl ether	1634-04-4	0.5 ppbv
m-ethyltoluene	620-14-4	1 ppbc
m-tolualdehyde	620-23-5	0.025 µg/ml
n-propylbenzene	103-65-1	1 ppbc
n-undecane	1120-21-4	1 ppbc
o-ethyltoluene	611-14-3	1 ppbc
o-xylene	95-47-6	1 ppbc
p-diethylbenzene	105-05-5	1 ppbc
propylene oxide	75-56-9	1 ppbv
pyrene	129-00-0	2 ng/m^3 (pql)
t-1,3-dichloropropene	10061-02-6	0.5 ppbv
tetrachloroethene	127-18-4	0.5 ppbv
trans-1,2-dichloroethylene	156-60-5	0.5 ppbv
trans-2-butene	624-64-6	1 ppbc
trans-2-pentene	646-04-8	1 ppbc
trichloroethene	79-01-6	0.5 ppbv
trichlorofluoromethane	75-69-4	0.5 ppbv
valeraldehyde	110-62-3	0.025 µg/ml
vinyl acetate	108-05-4	1 ppbv
vinyl bromide	593-60-2	0.5 ppbv
vinyl chloride	75-01-4	0.5 ppbv

[a]Reporting limit is mrl (method reporting limit) unless pql (practical quantification limit) is specified.

Table 2. Volatile chemicals detected in air samples in western Colorado from July, 2010 to October, 2011.

Chemical name	CAS #	*n* Detects	% Detects	Mean ppbv	Range ppbv	Std Dev ppbv	*n* Spikes
VOCs							
methane	74-82-8	48	100	2472.9	1600.0-5500.0	867.3	6
ethane	74-84-0	48	100	24.4	3.6-118.0	23.7	5
propane	74-98-6	48	100	9.3	1.1-46.7	9.0	7
toluene	108-88-3	48	100	1.2	0.4-4.3	0.9	4
isopentane	78-78-4	43	90	1.8	0.4-7.3	1.3	6
n-butane	106-97-8	42	88	3.2	0.8-14.0	2.6	4
isobutane	75-28-5	42	88	2.9	0.6-13.5	2.5	4
acetone	67-64-1	41	85	9.5	3.4-28.3	6.2	6
n-pentane	109-66-0	40	83	1.5	0.4-5.6	1.0	5
n-hexane	110-54-3	38	79	0.9	0.3-3.0	0.6	4
methylcyclohexane	108-87-2	36	75	0.9	0.3-3.1	0.6	4
methylene chloride	75-09-2	35	73	206.2	2.7-1730.0	357.4	4
m/p-xylenes	108-38-3/ 106-42-3	29	60	0.4	0.2-0.7	0.2	6
2-methylpentane	107-83-5	27	56	0.8	0.3-2.2	0.4	3
n-heptane	142-82-5	22	46	0.6	0.3-1.4	0.3	3
3-methylpentane	96-14-0	21	44	0.8	0.3-2.0	0.4	3
benzene	71-43-2	21	44	0.5	0.3-1.1	0.2	3
methanol	67-56-1	19	40	18.3	12.1-30.6	5.6	4
methylcyclopentane	96-37-7	18	38	0.6	0.3-1.3	0.3	3
cyclohexane	110-82-7	17	35	0.6	0.3-1.6	0.4	2
n-octane	509-84-7	15	31	0.4	0.2-0.8	0.2	3
3-methylhexane	589-34-4	12	25	0.5	0.3-1.1	0.3	1
2-butanone (mek)	78-93-3	10	21	3.4	2.3-5.1	1.0	2
2-methylhexane	591-76-4	9	19	0.4	0.2-0.7	0.2	2
ethylene	74-85-1	8	17	1.2	0.8-1.8	0.4	1
acetylene	2122-48-7	4	8	1.4	0.9-2.4	0.7	1
isoprene	78-79-5	4	8	0.6	0.4-0.7	0.2	0
n-nonane	111-84-2	4	8	0.2	0.2-0.3	0.0	1
2,3-dimethylbutane	79-29-8	3	6	0.4	0.4-0.5	0.1	1
ethanol	64-17-5	3	6	11.4	3.2-19.4	8.1	0
2-methylheptane	592-27-8	3	6	0.3	0.3	0.0	0
1,2,4-trimethylbenzene	95-63-6	2	4	na	0.2-0.3	na	0
tetrahydrofuran	109-99-9	1	2	na	2.1	na	0
styrene	100-42-5	1	2	na	0.9	na	0
ethylbenzene	100-41-4	1	2	na	0.7	na	0
cyclopentane	287-92-3	1	2	na	0.4	na	0
3-methylheptane	589-81-1	1	2	na	0.3	na	0

Table 2. (cont.)

Chemical name	CAS #	*n* Detects	% Detects	Mean ppbv	Range ppbv	Std Dev ppbv	*n* Spikes
isopropylbenzene	98-82-8	1	2	na	0.3	na	0
n-dodecane	112-40-3	1	2	na	0.3	na	0
Carbonyls							
formaldehyde	50-00-0	43	100	1.0	0.3-2.4	0.5	6
acetaldehyde	75-07-0	43	100	0.6	0.3-1.8	0.3	4
crotonaldehyde	123-73-9	42	98	1.3	0.1-3.0	0.8	8
mek &	78-93-3/						
butyraldehyde	123-72-8	37	86	0.2	0.0-0.4	0.1	7
hexaldehyde	66-25-1	9	21	0.1	0.1-0.2	0	2
propionaldehyde	123-38-6	6	14	0.1	0.1-0.2	0	1
benzaldehyde	100-52-7	5	12	0.1	0.1	0	1
methacrolein	78-85-3	5	12	0.1	0.1	0	1

na = not applicable. Statistics were not calculated for chemicals in which there were fewer than three detections.

Table 3. PAHs detected in air samples in western Colorado from October, 2010 to March, 2011.

Chemical name	CAS #	*n* Detects	% Detects	Mean pptv	Range pptv	Std Dev pptv	*n* Spikes
naphthalene	91-20-3	21	100	3.01	0.81-6.08	1.44	4
phenanthrene	85-01-8	16	76	0.36	0.21-0.61	0.14	4
fluorene	86-73-7	11	52	0.20	0.15-0.32	0.06	2
indeno(1,2,3-cd)pyrene	193-39-5	8	38	0.18	0.09-0.49	0.13	1
benzo(g,h,i)perylene	191-24-2	7	33	0.22	0.09-0.45	0.13	1
dibenzo(a,h)anthracene	53-70-3	7	33	0.20	0.11-0.51	0.15	1
benzo(a)pyrene	50-32-8	5	24	0.21	0.13-0.36	0.09	1
benzo(b)fluoranthene	205-99-2	5	24	0.20	0.13-0.26	0.05	1
benzo(k)fluoranthene	207-08-9	5	24	0.18	0.13-0.25	0.05	1
benzo(a)anthracene	56-55-3	2	10	na	0.13-0.16	na	0
chrysene	218-01-9	2	10	na	0.12-0.16	na	0
acenaphthylene	208-96-8	1	5	na	0.20	na	0

na = not applicable. Statistics were not calculated for chemicals in which there were fewer than three detections.

Table 4. Health effects[a] of chemicals detected in air samples collected in western Colorado.

Chemical Name	Sens	Resp	Gastr	Brain/ Nerv	Imm -une	Kidn	Card/ Bld	Canc/ Tum	Geno -toxic	Endo	Liver / Met	Othr
1,2,4-trimethylbenzene	X	X	X	X	X	X	X	X	X	X	X	X
2,3-dimethylbutane												
2-butanone (mek)				X		X				X	X	
2-methylheptane												
2-methylhexane												
2-methylpentane				X								
3-methylheptane												
3-methylhexane												
3-methylpentane				X								
acenaphthylene										X	X	X
acetaldehyde	X	X	X	X	X	X	X	X	X	X	X	X
acetone	X	X	X	X	X	X	X			X	X	X
acetylene												
benzaldehyde	X	X	X	X	X	X	X		X	X	X	X
benzene	X	X		X	X		X	X	X	X	X	X
benzo(a)anthracene	X	X						X	X		X	X
benzo(a)pyrene	X	X	X	X	X	X	X	X	X	X	X	X
benzo(b)fluoranthene		X			X	X		X	X	X	X	X
benzo(g,h,i)perylene									X			
benzo(k)fluoranthene					X		X	X	X	X	X	
butyraldehyde				X								
chrysene		X			X	X	X	X	X	X	X	X
crotonaldehyde		X	X	X	X	X	X	X	X	X	X	X
cyclohexane				X		X		X			X	
cyclopentane				X								
dibenzo(a,h)anthracene	X	X	X	X	X	X	X	X	X	X	X	X
ethane												
ethanol	X	X	X	X			X	X		X	X	X
ethylene											X	X
fluorene	X			X	X	X	X				X	X
formaldehyde	X	X	X	X	X	X	X	X	X	X	X	X
hexaldehyde	X			X	X		X		X	X		X
indeno(1,2,3-cd)pyrene		X		X	X			X	X	X	X	
isobutane												
isopentane												
isoprene	X	X	X	X	X	X	X	X	X	X	X	X
methacrolein	X	X										
methane												
methylcyclohexane												
methylcyclopentane				X								
methylene chloride	X	X	X	X	X	X	X	X	X	X	X	X
m-xylene	X	X		X	X	X	X			X	X	
naphthalene	X	X	X	X	X	X	X	X	X	X	X	X
n-butane				X			X					X

Table 4. (cont.)

Chemical Name	Sens	Resp	Gastr	Brain/ Nerv	Imm -une	Kidn	Card/ Bld	Canc/ Tum	Geno -toxic	Endo	Liver /Met	Othr
n-decane	X	X		X	X							X
n-heptane	X			X			X		X	X	X	
n-hexane				X	X		X			X	X	
n-nonane	X			X	X	X	X			X	X	X
n-octane	X	X		X	X	X	X			X	X	X
n-pentane												
phenanthrene	X	X		X	X		X			X	X	X
propane												
propionaldehyde					X				X			X
propylene	X	X		X	X	X				X	X	
p-xylene	X	X		X		X	X		X	X	X	X
tetrahydrofuran			X	X	X	X	X	X	X	X	X	X
toluene	X	X	X	X	X	X	X		X	X	X	X
Total	25	25	14	35	28	23	27	18	23	30	33	29

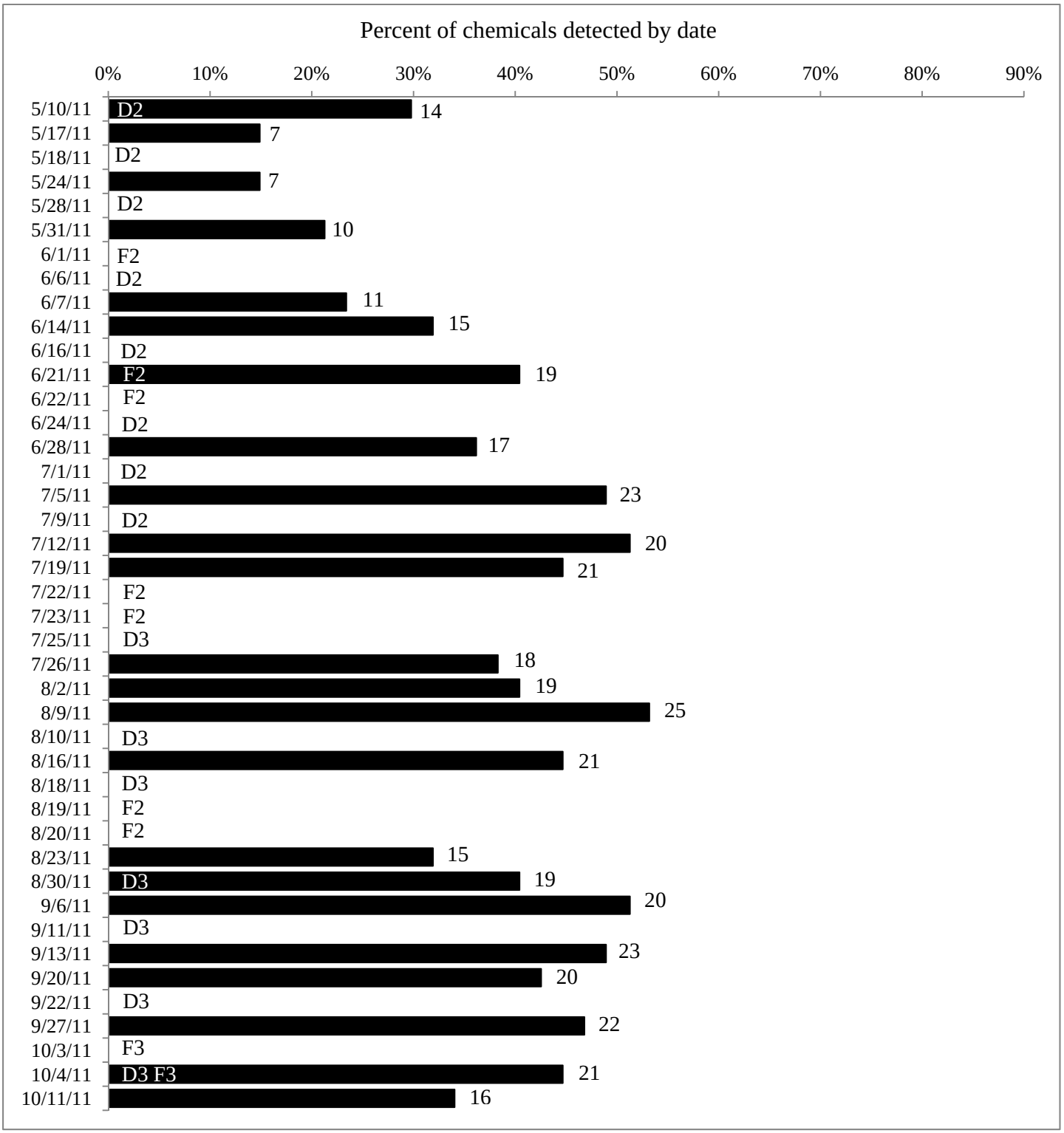
[a]Sens = skin/eye/sensory organ; Resp = respiratory; Gastr = gastrointestinal; Brain/Nerv = brain/nervous system; Immune = immune system; Kidn = kidney; Card/Bld = cardiovascular/blood; Canc /Tum = cancer/ tumorigen; Genotoxic = genotoxic; Endo = endocrine system; Liver/Met = liver/metabolic; Othr = other.

Figure 1. Percent and number[a] of chemicals detected in air samples collected in western Colorado from July, 2010 to October, 2011, and drilling/fracturing events, by date.

Figure 2. Number of chemical spikes[a] from air samples collected in western Colorado from November, 2010 to October, 2011, by compound type and date of sampling event.

Figure 1.


Percent of chemicals detected by date
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
7/17/10 Baseline 11
10/19/10 Baseline 32
10/22/10 D1
11/2/10 21
11/5/10 D1
11/9/10 15
11/16/10 D1 6
11/23/10 21
11/28/10 D1
11/30/10 19
12/7/10 32
12/9/10 D1
12/14/10 43
12/16/10 D1
12/21/10 27
12/23/10 D1
1/2/11 D1
1/4/11 F1 36
1/10/11 D1
1/11/11 38
1/18/11 34
1/20/11 D1
1/25/11 25
1/29/11 D1
1/31/11 34
2/7/11 D1
2/8/11 24
2/15/11 D1 F1 32
2/22/11 33
2/24/11 D1
3/1/11 30
3/6/11 D1
3/8/11 17
3/15/11 31
3/16/11 D1
3/23/11 25
3/26/11 Accident
3/29/11 18
4/3/11 D2
4/5/11 19
4/12/11 27
4/14/11 D2 F1
4/15/11 F1
4/16/11 F1
4/19/11 14
4/20/11 F1
4/23/11 D2
4/26/11 8
5/2/11 D2
5/3/11 15



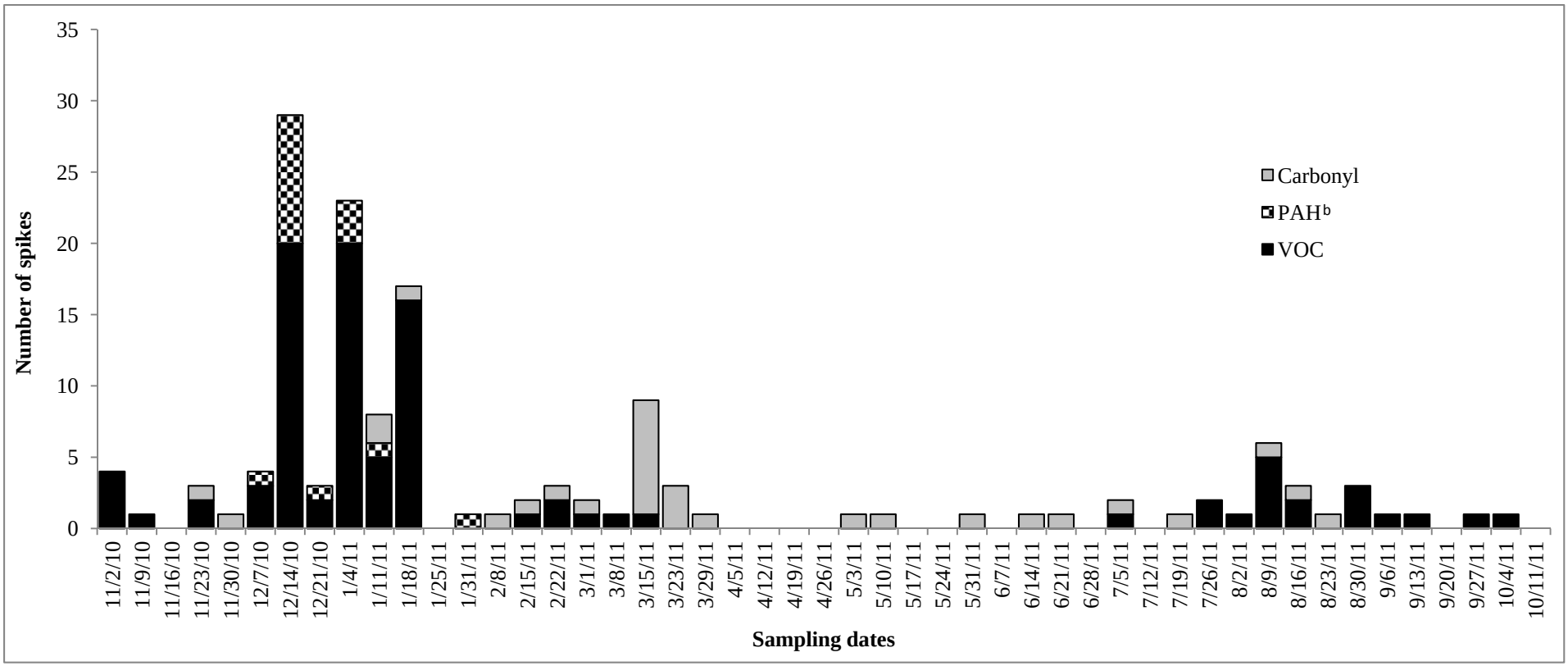
[a] The number of chemicals detected is shown at the end of each bar.

D1 FI: Drilling and fracturing events during development of Pad #1.

D2 F2: Drilling and fracturing events during development of Pad #2.

D3 F3: Drilling and fracturing events during development of Pad #3.

Figure 2.



[a] A spike is a detected chemical level that is at least one standard deviation above the mean.

[b] PAHs were sampled from 11/2/10 to 3/29/11.

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October 22, 2002

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RE: **An Analysis of Possible Increases in Exposure to Toxic Chemicals in Delta County, Colorado Water Resources as the Result of Gunnison Energy's Proposed Coal Bed Methane Extraction Activity**

BACKGROUND
Gunnison Energy is proposing to extract coal bed methane in Delta County, Colorado. In its notices to the public it makes claims that "…the threats posed by hydraulic fracturing of CBM wells to USDWs [US drinking water supplies] are low and do not justify additional study." They also claim that the "…fluids used to extract coal bed methane from the ground do not substantially threaten public health." [1] The following addresses these claims and looks at possible direct and indirect health effects of CBM extraction on the citizens, domestic animals, and wildlife in Delta County.

THE FRACTURING FLUIDS
Gunnison Energy proposes to use a solvent, ethylene glycol monobutyl ether (2-butoxyethanol), hereafter designated as 2-BE, in a liquid fracturing mixture to facilitate the extraction of coal bed methane in Delta County. 2-BE will be present in the liquid component of the fluid at approximately 7 ppm (parts per million) based on data provided to Delta County Commissioners following three local Area Planning Committee meetings by Gunnison Energy Corporation (GEC), May 29, 2002.

The structural formula for 2-BE is:

CH3-CH2-CH2-CH2-O-CH2-CH2-OH

2-BE is a highly soluble, colorless liquid with a very faint, ether-like odor.[2] At the concentration it is to be used in Delta County, it might not be detectable through odor or taste. 2-BE has low volatility, vaporizes slowly when mixed with water, and remains well dissolved throughout the water column.[2] Photolysis (degradation by sunlight) is not a factor in the breakdown of 2-BE. It mobilizes in soil and can easily leach into groundwater.[2] Because of these characteristics, it could remain entrapped underground for years and eventually migrate to a domestic well or to a surfacing spring. This contaminated water in

some cases might not reach wells, springs, and rivers in Delta County until long after GEC will have gone out of business.

The half-life of 2-BE in natural surface waters ranges from 7 to 28 days.[2] With an aerobic bio-degradation rate this slow, humans, wildlife and domestic animals could come into direct contact with 2-BE through ingestion, inhalation, dermal sorption, and the eye in its liquid or vapor form as the entrapped water reaches the surface. Aerobic biodegradation requires oxygen and therefore the deeper 2-BE is injected underground the longer it will persist. To date the aerobic biodegradation breakdown products of 2-BE have not been identified. The chemistry to detect the glycol ethers, including 2-BE, in environmental samples is very difficult and therefore there are few laboratories with the ability to accurately quantify its presence.[2]

DIRECT HEALTH EFFECTS OF 2-BE

Immediate/Direct

Following inhalation or swallowing, 2-BE is distributed rapidly to all tissues in the body via the blood stream in laboratory animals. When applied directly to the skin, 2-BE is rapidly absorbed.[2] In solution, it is absorbed more rapidly. It is broken down to its toxic component, 2-butoxyacetic acid (BAA) in both humans and laboratory animals following all three exposure pathways[3]. Breakdown and excretion of BAA through the urine is identical regardless of the pathway of exposure according to laboratory studies[3] No laboratory studies could be found that assessed cumulative effects from simultaneous ingestion, inhalation, and dermal exposure to 2-BE, which could be the scenario in Delta County.

Hemolytic Effects - Primary

The most critical direct effect of 2-BE as the result of laboratory studies is its impact on red blood cells. It causes hemolysis (breakdown of red blood cells) by dissolving the fat in the cell membrane and causing the membrane to break down. 2-BE causes hematuria (blood in the urine) and blood in the feces. Blood appears in the urine as a result of kidney damage which can eventually lead to kidney failure. It is especially toxic to the spleen, the bones in the spinal column, and bone marrow (where new blood cells are formed) and the liver, where chemicals are detoxified (broken down for easy excretion from the body).[2] Chronic exposure can cause anemia, and in laboratory animals it leads to insufficient blood supply, cold extremities, and tail necrosis (a condition where the tail rots away.)[4]

Other Effects - Secondary

In a sub-chronic study over a period of 14 weeks, mice exposed to 2-BE exhibited the hemolytic effects mentioned above as well as a number of secondary problems involving the spleen and liver, and degeneration of kidney tubules.[5] In addition, females were more sensitive to fore-stomach necrosis, ulceration, and inflammation occurring at half the dose required to cause the same problems in males. Female fertility was also significantly reduced in mice because of embryo mortality.[6] In this study, the dead embryos were discarded, and as a result, the prenatal effects of 2-BE on the embryos were not determined.

EPA recommends that 2-BE be classified as a mild eye irritant.[3] However, a recent study published after EPA reached this classification could lead to a higher risk classification. Using oral exposure in rats, severe damage to the eye was discovered that led to retinal

detachment, photoreceptor degeneration and occlusion resulting from multiple thrombosis of the blood vessels in the eye.[7] In this study, females were more susceptible.

With few exceptions most of the evidence mentioned above was derived from inhalation studies. All of the studies used standard, high-dose testing protocols to detect obvious birth defects and organ damage, cancer, mutations, convulsions, and skin and eye irritation. No long-term, multigenerational, chronic oral studies at environmentally relevant concentrations are available that could rule out prenatal damage.

Immunotoxicity

Early studies suggested that perhaps 2-BE does not affect the immune system[8,9], more recent studies using more sophisticated measures and lower doses have determined otherwise. In an early immunotoxicity study, the lowest doses significantly increased the natural killer (NK) cell response in males and females, and the highest doses induced no response.[9] The investigators never did find the lowest dose at which there would be no effect. However, they did not consider this an indication of adversity.

In another study, rats exposed to 2-BE in water for 21 days showed no structural effects in the liver or the testes, however their livers were significantly heavier and the animals experienced reduced body weight even at the lowest dose. However, they were surprised to find that at the lowest 2-BE dose NK cell responses were increased. A more recent study exposing female mice topically for 4 days once again confirmed the elevated NK cell response.[10]

A 2002 study reports that 2-BE at unusually low doses inhibits a normal contact hypersensitivity response in female mice.[11]

Carcinogenicity

At the end of a two year chronic bioassay, elevated numbers of combined malignant and non-malignant tumors of the adrenal gland were reported in female rats and male and female mice.[5] Low survival rates in the male mice in this study may have been the result of the high rate of liver cancers in the exposed animals.[5] This study revealed that long-term exposure to 2-BE often led to liver toxicity before the hemolytic effects were discernible. [5]

No human epidemiological studies are available to assess the potential carcinogenicity of 2-BE. However, from the results of laboratory studies, using Guidelines for Carcinogenic Risk Assessment (1986), 2-BE has been classified by the USEPA as a *possible human carcinogen.* [3]

SENSITIVE POPULATIONS

A number of laboratory studies confirmed that aging increases susceptibility to the effects of 2-BE. Older animals have reduced ability to metabolize the toxic metabolite BAA and this, combined with reduced kidney function that accompanies aging reduces their ability to excrete it in the urine.[3]

Females are more susceptible to the hematological effects in laboratory animal and human studies. There is an obvious gender and age sensitivity to 2-BE in humans as determined from accidental poisonings with females being more sensitive. In addition, among humans there may be sub-populations that might be more sensitive than others.[3]

A list of risk factors for people exposed to 2-BE includes those:
(1) using the pharmaceuticals hydralazine, dilantin, chloramphenicol, and sulfonamides;
(2) with infections, such as herpes, malaria, parasites, and rubella;
(3) with a family history of gallstones, cholestectomy, jaundice, Rh and APO positive;
(4) with iron deficiency; and
(5) with systemic illnesses, such as cardiac, gastrointestinal, liver, and kidney disease, and hypothyroidism.[3,12]

From a wildlife and domestic animal perspective, it is important to note that a variety of studies with laboratory animals revealed that some species are more sensitive to 2-BE than others.[3] For example, rats are more sensitive than mice to the toxic effects of 2-BE on the liver. No studies were found using wildlife or domestic animals.

INDIRECT HEALTH EFFECTS OF 2-BE

2-BE is widely used as an emulsifying agent and as a solvent for mineral oils[2]. This makes it an excellent candidate for releasing the natural, oily, coal-tar hydrocarbons found in coal that have been recognized for over a century to cause cancer.

CUMULATIVE AND AGGREGATE HEALTH HAZARDS

As mentioned above, no cumulative exposure studies have been done that evaluate the simultaneous impact of ingestion, inhalation, and topical exposure to 2-BE, which could be the mode of exposure to residents in Delta County. If 2-BE comes directly into the home via a well it will be used for drinking, bathing, showering, and doing laundry and dishes. Laboratory studies have revealed that in the case of bathing or applying 2-BE to the skin, it is readily absorbed through the skin rather than volatilizing. If water containing 2-BE is heated, as it comes out of the tap some of the 2-BE will off-gas into the home environment. Most of the studies mentioned above used inhalation as the pathway of exposure to 2-BE. Inhalation of 2-BE in the home could become a problem. For example, concern about exposure to the volatile by-products (trihalomethanes or THMs) in chlorine treated tap water [13] led to the discovery that taking a bath or a shower can lead to excessively high dose exposure to THMs. This exposure can exceed the level of exposure from drinking the water and add to the dose from drinking the water. Because of the volatility of 2-BE, the same pathway of exposure could become of concern for Delta County residents if 2-BE reaches their wells and especially if the water is heated.

Of increasing concern by federal health agencies are the *unpredictable,* interactive effects of mixtures of chemicals.[14] Under the scenario described in Gunnison Energy's prospectus, the concentrations of three classes of chemicals that are toxic individually at very low concentrations could become introduced or increased in the environment of Delta County. These include (1) the trace elements arsenic, molybdenum, and selenium, already a problem in Delta county, (2) a synthetic solvent, 2-BE, and (3) the polyaromatic hydrocarbons and coal tars found in coal beds. Arsenic, 2-BE, and aromatic coal bed tar derivatives are known carcinogens. In aggregate, whether their effects would be additive or synergistic has not been determined. However, in one study, the authors were surprised to find that 2-BE potentiated the lethality of low level exposure to another toxicant, a bacterially produced lipopolysaccharide (LPS) that is found in the human gut under certain conditions.[8]

Additional contamination of potable water could come from the impurities in the 2-BE product used in the extraction process. Commercial grade 2-BE can range in impurities depending upon the production process, manufacturer, and grade of the solvent. One impurity, sodium hydroxide (lye), a strong caustic, might possibly contribute to the alkalinity of the water. It was discovered in one product at 0.25%. Even high grade 2-BE with greater than 99% purity can contain 0.2% w/w ethylene glycol (anti-freeze), diethylene glycol, and diethyl monobutyl ether, sister compounds to 2-BE with much higher toxicity.[2]

ENVIRONMENTAL EFFECTS

Increased salinity

2-BE leaves an alkaline residue upon evaporation which might slightly add to the alkalinity problem that increases as surface water approaches the lower reaches of Delta County. Because of the solubility of sodium salts they can travel long distances in rivers and could increase the salinity problem in the Colorado River downstream.

Locally, any additional water that increases the salinity could also increase the mobilization of some of the alkaline soluble, problem elements such as arsenic and selenium, already posing health risks in Delta County. Health advisories are already in effect for Sweitzer Lake warning people not to eat the fish because of the high levels of selenium in the fish tissue.

A peer reviewed report by the US Forest Service on the threat of increased selenium contamination in the Mancos and La Plata River drainages describes a scenario similar to the Gunnison River drainage in Delta County where selenium is already at levels of concern.[15] The hazards include threats to wetlands, aquatic habitat, invertebrates, fish, birds and other wildlife reproduction. Delta County is in a unique and fragile situation – (1) it already has the natural geological existence of selenium, (2) its local hydrology that has been embellished and complicated through extensive irrigation activity, and (3) a climate prone to drought .

There is a growing collection of scientific papers on the adverse health effects of selenium in wildlife exposed to elevated concentrations of selenium in seep-like situations (natural and human-induced) in the West. Waterfowl, fish, and invertebrates have experienced decreased hatching success and increased birth defects as a result of exposure in the egg. Chicks of avocets, stilts, ducks, coots, etc. have been found with crossed bills, missing eyes, and other deformities in aquatic systems where irrigation run off water collects.

HEALTH RISKS TO BE TAKEN INTO CONSIDERATION

Although no standard has been established yet for 2-BE in drinking water, in 1993 the EPA set a minimum risk level (MRL) for 2-BE at 0.07 mg/kg/day based on an adult 70 kg male drinking two liters of water a day. This value is based on liver toxicity studies in rats and not on more sensitive immune, developmental, and functional health effects that have become of concern over the past decade. In 1998 EPA derived a reference dose RfD for 2-BE at 0.5 mg/kg/day for non-cancer effects. This is based on lifetime exposure. EPA admits " Since drinking water exposures are highly complex and variable, a simplifying assumption was used in all simulations ….". EPA had no human data to derive its value.[3]

GEC is planning to inject fluid into the ground in Delta County at 7 ppm. If this fluid reaches the taps in Delta County at that concentration, it will be providing 0.2 mg/kg/day

per two liters of water, approximately three times higher than the MRL and a little more than half the RfD.

RECOMMENDATIONS

1. First and most important, it is imperative to understand the hydrology of Delta County better. In addition, the complex diversions of potable water for irrigation and domestic use throughout the county must be factored into this knowledge.

2. Second, it is imperative to determine the current concentrations of the toxic chemicals in the coal bed water to be released during extraction prior to introducing the fracturing liquids. This must include the entire scope of trace elements from alkaline to acid based derivatives in both their dissolved and suspended form. In addition, the entire scope of polyaromatic hydrocarbons (both parent and alkylated forms) in the underground coal bed water should be quantified prior to any activity. Because of the toxicity of the elements and compounds of concern, detection limits throughout this monitoring should be no higher than a part per trillion. Information such as this will allow for determining if the fracturing liquid releases additional toxic components, and in the case of the PAHs, through dissolution by the 2-BE.

3. Throughout the mining life of the well, the underground fluid with which it will interface should be monitored on a regular basis for its toxic components. See those components mentioned in Number 2. If the concentrations of the contaminants decrease, this could indicate that precious potable subsurface or surface water is being drained from above. This provides an approach for detecting dewatering before too much potable water is lost.

4. If exploration begins, GEC must keep daily inventories of the total amount of fracturing liquid injected, including the exact amount of each component in the fluid.

5. GEC should be required to retrieve all surfacing liquid for containment. The volume of the retrieved liquid should be reported and the concentrations of the chemicals in that liquid quantified on a regular basis for auditing purposes to account for the toxic chemicals that were introduced under Number 4.

5. GEC's plans for disposal of this toxic liquid should be presented to the residents of Delta County for approval before any leases are approved.

6. Any changes in the composition of the fracturing liquid must be reported to the citizens of Delta County for consideration before the liquid is used.

7. If GEC should find that it needs or wants to use anything other than sand for propping, it must provide to the citizens of Delta County for consideration all the components in the alternative material before the material is used. The purity of the alternative products used must be provided as well. Trade names will not be acceptable.

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[1] The Daily Sentinel, Sunday, September 8, 2002. p. 8C

[2] Agency for Toxic Substances and Disease Registry . US Department of Health and Human Services. (1998) Toxicological Profile of 2-Butoxethanol and 2-Butoxyethanol Acetate.

[3] US Environmental Protection Agency. Toxicological Review of Ethylene Glycol Monobutyl Ether (EGBE) In Support of Summary Information on the Integrated Risk Information System (IRIS), October 1999

[4] Nyska A, Maronpot RR, PH Long, JH Roycroft, JR Hailey, GS Traylor, BI Ghanayem (1999) Disseminated thrombosis and bone infarction in female rats following inhalation exposure to 2-butoxyethanol. Toxicol Pathol 27(3):287-294.

[5] National Toxicology Program (NTP). 1998 NTP Technical report on the toxicology and carcinogenesis studies of 2-butoxyethanol (Cas No. 111-76-2) in F344/N rats and B6C3F1 mice (inhalation studies). US Department of Health and Human Services, Public Health Service, National Institutes of Health, Research Triangle Park, NC NTP TR 484. NIH Draft Publ. No. 98 -3974.

[6] Heindel,JJ, Gulati, DK, Russell, VS, et al. (1990) assessment of ethylene glycol monobutyl and monoethyl ether reproductive toxicity using a continuous breeding protocol in Swiss CD-1 mice. Fundam Apply Toxicol 15:683-696.

[7] Nyska A, RR Maronpot, BI Ghanayam. (1999) Ocular thrombosis and retinal degeneration induced in female F344 rats by 2-butoxyethanol. Hum Exp. Toxiol 18(9):577-582.

[8] Smialowicz, RJ, Williams, WC, Riddle,MM. etal. (1992). Comparative immunosuppression of various glycol ethers orally administered to Fischer 344 rats. Fundam Apply Toxiocl 18:621-627.

[9] Exon JH, GG Mather, JLBussiere, DP Olson, PA Talcott. (1991) Effects of subchronic exposure of rats to 2-methoxyethanol or 2-butoxyethanol: thymic atrophy and immunotoxicity. Fudam Appl Toxicol 16(4):830-840.

[10] Singh P, Zhao S, Blaylock RL. ()2001). Topical exposure to 2-butoxyethanol alters immune responses in female BALB/c mice. Int Jrl Toxicol 20:383-390.

[11] Singh P, Morris B, Zhao S, Blaylock RL. (2002) Suppresssion of the contact hypersensitivity response following topical exposure to 2-butoxyethanol in female BALB/c mice. Int Jrl Toxicol, 21:107-115.

[12] (Berliner N, Duffy, TP, Abelson HT. (1999) Approach to adult and child anemia. In: Hoffman, R ed. Hematology:Basic Principles and Practice. 2nd ed. New York, NY: Churchill Livingtsone, pp.468-483.

[13] Nester AM, Singer PC, Ashley DL, Lynberg MC, Mendola P, Langlois PH, Nichols JR. (2002). Comparison of trihalomethanes in tap water and blood. Env Sc Techn. 36(8):1692-1698.

[14] Department of Health and Human Services, Agency for Toxic Substances and Disease Registry , (2001). Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures. Draft for Public Comment.

[15] Lemly AD (1997). Environmental hazard of selenium in the Animas La Plata water development project. Ecotoxicol Environ Safety 37:92-96.

Exhibit F

Renewable Energy Alternative Options

Compiled By Jody McCaffree

This offshore wind farm became operational in late 2008 off the coast of Lincolnshire, England. This Lynn and Inner Dowsing wind farm generates power for 130,000 homes. [Photo source: http://ecoble.com/2009/09/08/the-worlds-most-amazing-wind-farms/]

WHY WOULD RATEPAYERS WANT TO PAY MORE FOR KILOWATTS PRODUCED FROM OUTDATED, UNRELIABLE AND POLLUTING FOSSIL FUELS WHEN CHEAPER, CLEANER, MORE RELIABLE KILOWATTS ARE READILY AVAILABLE?

A decentralized energy system that is sustainable and can be democratized with local ownership will be what spreads the production of energy in the future and the economic benefits of that are as far and wide as the renewable energy resource is itself… And we now know renewable energy can literally be found on every square inch of the planet.

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A VISUAL UNDERSTANDING OF THE ISSUES

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* A Crude Awakening – The Oil Crash (trailer)

http://www.oilcrashmovie.com/

* FUEL the Movie (trailer)

"Fuel" is a vital, superbly assembled documentary that presents an insightful overview of America's troubled relationship with oil and how alternative and sustainable energies can reduce our country's and the World's addictive dependence on fossil fuels. More info at www.thefuelfilm.com

http://www.youtube.com/watch?v=FsP5EmMrTqk (2:17 min)

* Decentralized Power – What are we waiting for?

http://www.youtube.com/watch?v=klooRS-Jjyo (17min – ***Prepare to be enlightened***!)

* Time for energy consumers and ratepayers to have a FIT… ! Understanding what a FIT is:

http://www.oregonrenewables.com/Resources/Introductory_Video.html (5 min – ***You won't be bored***)
Below find another video similar to the above video link (10:40 min)
http://www.youtube.com/watch?v=3H3lRTQSJxY&feature=related

* Carbon Nation – Movie Trailer

A climate change solutions movie [that doesn't even care if you believe in climate change]
http://carbonnationmovie.com/ (2:24 min)

LINKS TO REPORTS AND GUIDELINES FOR RENEWABLE ENERGY SUCCESS

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http://pacificenvironment.org/base2020

Clean Energy Plan for San Francisco Bay Area Will Reduce Emissions, Lower Energy Bills, and Create Jobs

March 12, 2012

Pacific Environment released a report on March 12, 2012, "**Bay Area Smart Energy 2020**" (BASE 2020), which details how the San Francisco Bay Area can move to a locally-based, clean energy economy and leave fossil fuels behind. Currently available energy technologies, coupled with existing state policies, can transform the 9-county Bay Area electricity grid to achieve the following by 2020:

- A reduction in greenhouse gas emissions of over 60 percent from the electricity sector, or 12 million tons per year.
- 25 percent of Bay Area homes and businesses being "zero net energy," creating the power they need on-site, leading to huge energy cost savings.
- Tens of thousands of new jobs building the energy grid of the future.
- Cleaner, healthier air in the Bay Area…

The report provides a "how-to" guide for how the region can maximize local resources to dramatically reduce fossil fuel dependence. It emphasizes roof-top solar and energy efficiency strategies, and recommends policies that can create the best incentives for residents and businesses to maximize energy production on their own site. It favors local energy projects owned by residents and businesses over those controlled by utilities….

(Read more, link to report, at link above)

The Huffington Post
http://www.huffingtonpost.com/2011/01/25/100-percent-renewable-ene_n_813256.html/

100 Percent Renewable Energy Achievable By 2030: Study

By Joanna Zelman - Originally Posted: 01/25/11 – Updated 05/25/11

"…Could the world reach a 100 percent renewable energy goal in less than 20 years? New research says we can.

A report published in the journal Energy Policy claims that by 2030, the world can achieve 100 percent renewable energy if the proper measures are taken.

What exactly are these measures? According to PhysOrg, over 80 percent of our world's energy supply currently comes from fossil fuels. We would need to build approximately four million wind turbines, nearly 2 billion solar photovoltaic systems, and about 90,000 solar power plants. The 5 MW wind turbines needed are up to three times the capacity of most of our current wind turbines…."
(*Read entire article, link to report, at link above)*

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Scientific American
http://www.scientificamerican.com/article.cfm?id=a-path-to-sustainable-energy-by-2030

A Plan to Power 100 Percent of the Planet with Renewables

Wind, water and solar technologies can provide 100 percent of the world's energy, eliminating all fossil fuels. Here's how
By Mark Z. Jacobson and Mark A. Delucchi | October 26, 2009

"…Scientists have been building to this moment for at least a decade, analyzing various pieces of the challenge. Most recently, a 2009 Stanford University study ranked energy systems according to their impacts on global warming, pollution, water supply, land use, wildlife and other concerns. The very best options were wind, solar, geothermal, tidal and hydroelectric power—all of which are driven by wind, water or sunlight (referred to as WWS). Nuclear power, coal with carbon capture, and ethanol were all poorer options, as were oil and natural gas. The study also found that battery-electric vehicles and hydrogen fuel-cell vehicles recharged by WWS options would largely eliminate pollution from the transportation sector…"
(*Read entire article/report at link above*)

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The New York Times – Blog
http://greeninc.blogs.nytimes.com/2009/10/30/report-argues-for-a-de-centralized-system-of-renewable-power-generation/

Report Argues for a Decentralized System of Renewable Power Generation

by Jim Witkin – The New York Times – Green Inc. – *Energy, the Environment and the Bottom Line*
Oct 30, 2009
(Read entire article at link above)

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Institute for Local Self-Reliance
http://www.ilsr.org/energy/publications/energy-selfreliant-states-second-and-expanded-edition/

Energy Self-Reliant States 2nd edition (also new wind estimates May 2010)

Energy Self-Reliant States: Second and Expanded Edition ; Originally Published October 2009 -

"…How self-sufficient in energy generation could states be if they relied only on their own renewable resources? In November 2008, ILSR began to address this question in the first edition of *Energy Self-Reliant States*. That report included a limited set of resources – on-shore wind and rooftop solar photovoltaic (PV) – and also examined the potential for biomass-derived transportation fuels.

This updated edition of Energy Self-Reliant States narrows the focus to electricity, but includes virtually all renewable resources (on shore and off shore wind, micro hydro, combined heat and power, geothermal, rooftop PV). The report also discusses the potential gains from improving energy efficiency and estimates the per kWh costs for each state to become energy independent.

The data in this report suggest that every state could generate a significant percentage of its electricity with homegrown renewable energy. **At least three-fifths of the fifty states could meet all their internal electricity needs from renewable energy generated inside their borders. Every state with a renewable energy mandate can meet it with in-state renewable fuels.** And, as the report discusses, even these estimates may be conservative…."
(*Read more, link to report, at link above*)

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http://www.newrules.org/sites/newrules.org/files/ESRS.pdf

Energy Self-Reliant States: 2009 Second and Expanded Edition

John Farrell jfarrell@ilsr.org; David Morris dmorris@ilsr.org;
Publication of The New Rules Project – Published October 2009

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Designed by an Arizona State University student, freeway sign wind turbines like these could generate enough electricity to supply a small apartment at low wind speeds and require no additional land usage.

American Wind Energy Association
http://www.newwindagenda.org/

Wind energy for a new Era

November 2008

The U.S. Department of Energy's report concludes that the U.S. possesses sufficient and affordable wind resources to obtain at least 20% of its electricity from wind. Wind energy generates electricity from a domestic, safe and inexhaustible source. Wind energy can reduce natural gas demand by 50% in the electric sector and 11% overall, relieving supply and price pressure in the domestic natural

gas market and potentially reducing future need for imported liquefied natural gas. Wind energy potentially reduces U.S. reliance on foreign oil by generating electricity that can be used for plug-in hybrid vehicles.
(*Read more, link to report, at link above*)

Stanford
http://news.stanford.edu/news/2012/september/offshore-wind-energy-091412.html

Offshore wind energy could power entire U.S. East Coast, Stanford scientists say

Stanford scientists deliver the first-ever quantitative analysis of offshore wind energy on the U.S. East Coast. They conclude there is enough wind energy to fulfill one-third of the U.S. energy demand.
Stanford Report, September 14, 2012
By Bjorn Carey

(*Read entire report at link above*)

Clean Technica
http://cleantechnica.com/2012/09/10/wind-energy-could-meet-global-demand-20-100-times-over-new-study-finds/

Wind Energy Could Meet Global Demand 20–100 Times Over, New Study Finds

September 10, 2012, By Nathan

All of the world's energy needs could be provided for solely by wind power, according to new research from the Carnegie Institute and the Lawrence Livermore National Laboratory.

The winds are capable of providing more than enough energy to meet all of the world's demands. The potential of atmospheric turbines is a part of that, capable of converting the much faster and steadier high-altitude winds into electricity (rather than ground- and ocean-based units).

The new research from the Carnegie Institute investigates what the actual limits of wind power are; how much could potentially be harvested; and what the effects of such large-scale, high-altitude wind power would be — could they affect the whole climate themselves?…

…."Looking at the big picture, it is more likely that economic, technological or political factors will determine the growth of wind power around the world, rather than geophysical limitations," Caldeira said.

The research was just published on September 9th in the journal Nature Climate Change….

(*Read entire article at link above*)

US News

http://www.usnews.com/news/articles/2012/09/10/4-million-wind-turbines-could-support-about-half-of-2030-energy-demand

4 Million Wind Turbines Could Support About Half of 2030 Energy Demand

A new study suggests there's more potential in wind power than previously thought

September 10, 2012

By Jason Koebler

Wind energy could provide up to half the world's power supply with little environmental impact, according to a new study by researchers at the University of Delaware and Stanford University.

The study debunks previous assessments that suggested wind wouldn't be a feasible way to power much of the world's grid due to environmental and power output concerns. According to the University of Delaware's Cristina Archer, about 4 million turbines could provide the world with 7.5 terawatts of energy annually, about half of the estimated power necessary to run earth's power grids in 2030….

…"**Four million turbines is a lot, but it's not impossible. We have to decide whether we want to do it. The benefits are immense—we'd have a clean economy and we'd be getting rid of pollution," Archer says. "If society wants to do it, the technology is there—it's not like we have to invent cold fusion from scratch**."… (*Emphasis added*)

(*Read entire article at link above*)

Sustainable Conservation

http://suscon.org/cowpower/biomethaneSourcebook/biomethanesourcebook.php

Cow Power

Biomethane from Dairy Waste: A Sourcebook for the Production and Use of Renewable Natural Gas in California

Prepared for Western United Dairymen

Michael Marsh, Chief Executive Officer

July 2005

Chapter 3: Upgrading Dairy Biogas to Biomtheane and Other Fuels

http://www.suscon.org/news/biomethane_report/Chapter_3.pdf

CLEANER IS CHEAPER

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http://solveclimate.com/blog/20091026/100-renewables-2030-less-fossil-power-case-made

100% Renewables by 2030 for Less Than Fossil Power: A Case is Made

by Stacy Feldman – Oct 26th, 2009; Solve Climate – Daily Climate News and Analysis ;

(*Read entire article at link above*)

Institute for Local Self-Reliance

http://www.ilsr.org/local-energy-valuable/

The More Local the Energy, the More Valuable

John Farrell | Updated on Apr 24, 2012

(*Read more, view graph, at link above*)

Institute for Local Self-Reliance

http://www.ilsr.org/lots-solar-power-reduce-increase-electricity-prices/

Lots of Solar Power May Reduce, Not Increase, Electricity Prices

John Farrell | Updated on Apr 4, 2012

"…Whether German feed-in tariffs or U.S. tax incentives, opponents of solar rail at its perceived high cost. But a story making rounds this week, "**why power generators are terrified of solar**," presents a powerful image that may flip this conventional wisdom on its head. Building lots of solar power can actually reduce electricity prices, to the dismay of utilities…."
(*Read more, link to report, at link above*)

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http://www.seia.org/research-resources/solar-means-business-top-commercial-solar-customers-us

Solar Means Business: Top Commercial Solar Customers in the U.S.

by Solar Energy Industries Association
Sep 11, 2012

Solar energy is being deployed on a massive scale by the most iconic brands and best-managed companies in the U.S. in order to help lower operating costs and increase profits. The Solar Energy Industries Association (SEIA) and the Vote Solar Initiative (Vote Solar) have unveiled a report naming the companies using solar on their facilities in the U.S., ranked by cumulative solar energy capacity.

Introduction

What do Walmart, Costco, IKEA, McGraw Hill, Johnson & Johnson and FedEx have in common? They know a smart investment when they see one, and are all adopting solar energy in a big way. From the largest corporations to small businesses, U.S. companies are installing solar energy to take control of their energy costs and improve their bottom line. As of mid--2012, businesses as well as non--profit organizations and governments across the United States have deployed more than 2,300 megawatts (MW)1 of solar electric (photovoltaic or PV) systems on more than 24,000 individual facilities—and this number is growing rapidly; during the first half of 2012, over 3,600 non--residential PV systems came online, an average of one every 72 minutes…. (*Emphasis added*)

(*Read entire overview at link above. Learn more at: www.seia.org/top20Solar*)

Bloomberg Businessweek
http://www.businessweek.com/news/2012-01-27/renewables-from-vestas-to-suntech-plan-profit-without-subsidy.html

Renewables From Vestas to Suntech Plan Profit Without Subsidy

January 27, 2012, 2:47 PM EST
By Alex Morales and Jacqueline Simmons
(Click DAVOS at link above for more on the World Economic Forum.)

"…(Bloomberg) — Renewable energy companies are approaching the point where they can generate electricity at a price competitive with fossil-fuels without subsidies, the biggest wind and solar manufacturers said.

Suntech Power Holdings Co. Chief Executive Officer Zhengrong Shi said solar will reach parity with fossil fuels on electric grids by 2015. Vestas Wind systems A/S expects its turbines to compete without incentives "in the coming years," said Peter Brun, head of governmental relations.

"Wind in some cases already is, or can in coming years, be fully cost-competitive with fossil fuels," Brun said yesterday by e-mail from the World Economic Forum in Davos, Switzerland…"

"…Solar power will be "very competitive" within a decade, and in some places, it's already near "grid parity," meaning it can compete without subsidies, Trina Solar Ltd. Chief Executive Officer Jifan Gao said in an interview in Davos. He spoke through an interpreter.

"We see costs coming down and manufacturing efficiency being improved all the time," said Gao, whose company is the fifth biggest maker of silicon-based solar panel. "In places like Australia, this year they will reach grid parity; next year Italy will, and in 2014 regions like California."

Gao's comments support those of Suntech's Shi, who told Bloomberg television that with government support, the industry has made "tremendous progress," and solar prices have been cut in half in a year.

"We believe that by 2015, there will be around 50 percent of countries where it reaches grid parity," Shi said…."
(*Read entire article at link above*)

Clean Technica
http://cleantechnica.com/2011/04/21/wind-power-beats-nuclear-power-in-texas/?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+IM-cleantechnica+%28CleanTechnica%29

Wind Power Beats Nuclear Power in Texas

By Tina Casey
April 21, 2011

"….For that matter, another facility in New York, the Shoreham nuclear power plant, had to be decommissioned before it ever went online, partly because planners failed to account for population growth in nearby suburbs. **Ratepayers were stuck with the tab and the facility still sits there, sucking up valuable real estate**…. ….Apparently, NRG's partner Toshiba is still intending to move ahead with the permitting process. Toshiba signed onto the project just two years ago in 2009, which is pretty much a blip on the screen in nuclear construction terms, so it's no surprise that the company hasn't thrown in the towel yet. However, given that wind power is set to take off not only in western U.S. states but all up and down the East Coast as well, the prospects for nuclear look pretty dim…."
(*Emphasis added – Read entire article at link above*)

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NC WARN
http://www.ncwarn.org/2010/07/solar-and-nuclear-costs-the-historic-crossover/

Solar power now cheaper than nuclear

By Dr. John O. Blackburn and Sam Cunningham
- July 8th, 2010

Proposed new nuclear plants would generate power at a cost of 14 to 18 cents per kilowatt-hour. But commercial-scale solar developers are already offering utilities electricity at 14 cents or less per kWh. A report, **"Solar and Nuclear Costs — The Historic Crossover,"** by Dr. John Blackburn, finds that states with open competition for electricity sales are rejecting new nuclear plants for solar, wind, cogeneration and energy efficiency.
(*Read more, link to report, at link above*)

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Report –

Easing the Natural Gas Crisis: Reducing Natural Gas Prices through Increased Deployment of Renewable Energy and Energy Efficiency;

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY; Ryan Wiser, Mark Bolinger, Matt St. Clair; Environmental Energy Technologies Division; January 2005; LBNL-56756; Download from http://eetd.lbl.gov/EA/EMP
http://www.lbl.gov/Science-Articles/Archive/sabl/2005/February/assets/Natural-Gas.pdf

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RENEWABLE RESOURCES ARE VAST

Clean Technica
http://cleantechnica.com/2012/01/07/riches-of-renewable-energy-in-u-s-revealed-by-free-online-atlas/?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+IM-cleantechnica+%28CleanTechnica%29

Riches of Renewable Energy in U.S. Revealed by Free Online Atlas

By Tina Casey
January 7, 2012

"…A free online atlas of renewable energy resources in the U.S.A. is now available courtesy of the National Renewable Energy Laboratory. Though designed for policymakers and planners, the new "RE Atlas" is a user-friendly interface that provides anyone who can use a computer with a vivid picture of the vast potential this country has for safe, low risk forms of energy including solar, wind and geothermal…"
(*Read more, link to atlas, at link above*)

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http://www.windenergy.com/content/commercial/commercial-case-studies

Winds of Change Blowing at Sam's Club in Palmdale, California

(2:36 min)

Popular Mechanics
http://www.popularmechanics.com/science/energy/solar-wind/can-floating-turbines-save-wind-power

Can Floating Turbines Save Wind Power?

Two new concepts for floating wind turbines put the future of wind energy out to sea.
By Stephanie Warren
December 22, 2011

"…**The best place to build the wind farms of the future is the open ocean**. While the breeze can be frustratingly variable on land, if you travel just 20 miles off the coastline, the wind blows at a consistent clip of around 33 feet per second…"
(*Read entire article, view prototypes, at link above*)

Clean Technica
http://cleantechnica.com/2010/06/26/14-million-acres-of-land-in-u-s-for-solar-energy-and-wind-farms/

14 Million Acres of Land in U.S. for Solar Energy and Wind Farms

Source: Clean Technica
By Tina Casey
June 26, 2010

"…If you take all the abandoned and classified former industrial sites and dumps across the U.S. and add them together, you get 14 million acres of cheap, available land that could be used as sites for new solar installations and wind farms. Right now the U.S. EPA is pushing forward with just such a plan, with the National Renewable Energy Laboratories (NREL) helping to assess brownfields and Superfund sites for renewable energy. The program is called Re-Powering America's Land. It also has a green jobs angle, through Recovery Act funding. Many of the potential sites are located in or near existing communities and could provide new jobs for local residents.

But wait, there's more. In addition to providing new green jobs and clean energy for local use or the wider grid, the program also focuses on green remediation, which uses renewable energy to power equipment used for site cleanup. **When you add that up – harvesting clean energy from land that is blighted and usable for not much else, while creating jobs and restoring the site, you gotta wonder why anybody would want to continue blowing up America's mountains, compromising our water supply, and destroying the Gulf of Mexico in pursuit of fossil fuels**…."
(*Emphasis added – Read more at link above*)

The Register Guard
http://www.registerguard.com/csp/cms/sites/web/opinion/22324802-47/story.csp

"Biogas wrongly ignored as an alternative source of energy"

by Warren Weisman, The Register Guard; Monday, Nov 2, 2009, page A9; Guest viewpoint:

"…If you have never heard of biogas, you are not alone. Widely used throughout Europe and Asia, this little-known alternative energy source produces many times more British thermal units than solar panels or wind turbines, at a fraction of the cost…"

"…Biogas is a combination of gases, consisting mostly of methane, produced during the natural decomposition of organic matter in an airtight environment. Methane is the same flammable component found in the fossil natural gas — only instead of taking 65 million years to make, biogas can be made in 48 hours to 72 hours…"
(*Read entire guest viewpoint at link above*)

Scientific American
http://www.scientificamerican.com/article.cfm?id=air-algae-us-biofuel-flight-on-weeds-and-pond-scum

Air Algae: U.S. Biofuel Flight Relies on Weeds and Pond Scum

The U.S.'s first commercial jet flight powered by biofuel runs one engine on African weed mixed with a smidgen of algae
By David Biello | January 7, 2009

"…Continental jet 516—a two-engine Boeing 737-800—completed a two hour test flight out of Houston today with one engine powered by a 50-50 blend of regular petroleum-based jet fuel and a synthetic alternative made from *Jatropha* and algae…."

"…In fact, the alternative jet fuel—known as synthetic paraffinated kerosenes—has as good or better qualities than Jet A refined from petroleum: It does not freeze at high-altitude temperatures, delivers the same or more power to the engines, and is lighter, as well. And

the refiners, UOP, LLC, a division of Honeywell, can turn almost any plant oil into the alternative jet fuel. “They’re all the same as far as we’re concerned. We’re feedstock agnostic,” says chemist Jennifer Holmgren, UOP’s general manager of the renewable energy and chemicals business.. “If the feedstock is available, we can process it to make fuels of the same capability.”…”

“…”Crude oil is nothing but algae from 10 million years ago during a great algae bloom that got transported underground and today we call it crude oil,” says Tim Zenk, vice president of corporate affairs at Sapphire Energy. “We take that process and speed it up by 10 million years and produce green crude.”…” (*Read entire article at link above*)

The facts - Natural Gas made from Biogas sources (organic waste, manure, landfills, etc) instead of from fossil fuel sources would eliminate many of these environmental problems and create thousands of jobs. We have plenty of biogas sources if we just look.

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http://thefraserdomain.typepad.com/energy/2008/01/all-eu-natural.html

“Biogas Could Replace All EU Natural Gas Imports From Russia”

January 08, 2008

“…Last year, the German Greens (Grüne) commissioned a report on the potential of biogas in Europe. The Öko-Instituts and the Institut für Energetik in Leipzig carried out the study and came to some startling conclusions: **Germany alone can produce more biogas by 2020 than all of the EU’s current natural gas imports from Russia.…”**
(*Read more at link above*)

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http://www.reuters.com/article/2008/03/04/environment-energy-cows-dc-idUSN0440606220080304

California cows start passing gas to the grid

By Nichola Groom - RIVERDALE, California | Tue Mar 4, 2008 6:30pm EST

“…RIVERDALE, California (Reuters) – Imagine a vat of liquid cow manure covering the area of five football fields and 33 feet deep. Meet California’s most alternative new energy.

On a dairy farm in the Golden State’s agricultural heartland, utility PG&E Corp began on Tuesday producing natural gas derived from manure, in what it hopes will be a new way to power homes with renewable, if not entirely clean, energy.

The Vintage Dairy Biogas Project, the brainchild of life- long dairyman David Albers, aims to provide the natural gas needed to power 1,200 homes a day, Albers said at the facility’s inauguration ceremony.

“When most people see a pile of manure, they see a pile of manure. We saw it as an opportunity for farmers, for utilities, and for California,” Albers said.…”
(*Read entire story at link above)*

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http://www.youtube.com/watch?v=wL6AQgLUPH0
Sep 27, 2009 / 5:55 min

18 years of Success:
Biogas Production at Fairgrove Farm.

Fairgrove Farms in Michigan, a 720-head dairy farm, produces biogas from manure and earns a profit after providing all the electricity needed for the farm. In the following video, shot in 1991, production had at that time gone largely uninterrupted for 18 years. The facility is an example of a fairly low-tech design which needs little repair or renewal over time.
Uploaded by dginia

Indiana Public Media
http://indianapublicmedia.org/news/indianas-biotown-usa-living-29762/

Indiana's BioTown USA Living Up To Its Name

By JOE HREN
Posted August 3, 2012

Driving through this small Indiana town of close to 500, there are no indications that it's the center of cutting edge technology. This town of Reynolds is being powered from something that will never be in short supply around here – manure.

"We are taking gas from poop and running the big engines and making electricity," says local farmer and president of BioTown Ag Brian Furrer. He is overseeing the project that has peaked the interest of people all over the world.

"People in the corporate world and throughout are talking about sustainability on a day to day basis, and I'm not sure they understand the true definition of sustainability and to me sustainability means we have a never ending supply and that's really what we are truly trying to do on this farm."

At heart, Furrer says he's just a farm boy despite working to make Reynolds the first energy self-sufficient community in America….

(*Read more at link above, link to video below*)
3:24 min

Athletic Business
http://www.athleticbusiness.com/articles/article.aspx?articleid=3757&zoneid=1

California High School Targets Grid Neutrality with Wind, Solar Power

By Michael Popke
July 2011

Architect Jorge de la Cal can't definitively say that the new net-zero high school he designed in San Pedro, Calif., is the first of its kind. But he's pretty sure there will be nothing else like it when the 115,000-square-foot facility opens in September 2012.

Los Angeles Unified School District's South Region High School #15, conceived by L.A.-based CO Architects (of which de la Cal is a principal) will hold up to 1,200 students and serve as an annex to nearby San Pedro High School. It is expected to achieve LEED Gold status with its grid neutrality — meaning that the $74 million facility will produce as much electricity as it consumes. More than 32,600 square feet of solar panels covering nearly every possible square foot of roof space, along with 36 bird-safe Vertical-axis wind turbines, will harness the sun and wind. Other sustainable elements include shaded and operable windows, daylighting, highly efficient HVAC

systems and air filters, water-saving installations, interior materials featuring recycled content, energy-smart fluorescent lights, and low-emitting ceiling tiles, flooring and insulation.….

…**One of the greatest challenges with this net-zero project, de la Cal says, was working through the bureaucracy of the nation's second-largest public school district and developing a district sustainability team to champion the cause**….
(*Emphasis added*)
(*Read entire article at link above*)

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Example of Vertical-Axis wind turbines in action
http://www.youtube.com/watch?v=jvcEkoWU3vo&hd=1
(1:41 min)

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http://www.scientificamerican.com/article.cfm?id=trash-based-biofuels

Trash-Based Biofuels: From Landfill to Full Tank of Gas

Lawn clippings and unrecycled paper could help break the world's oil addiction
By David Biello | February 12, 2008

"….BlueFire estimates 40 billion gallons of cellulosic ethanol could be produced from plant waste destined for the landfill, providing as much as one third of all U.S. transportation fuel needs. And, if other forms of waste, such as the stalks of corn plants (corn stover) or the remnants of timber harvestare included, Klann says, "we have enough feedstock in the U.S. to offset 70 percent of the oil import."…."
(*Read entire article at link above*)

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http://www.seco.cpa.state.tx.us/re_biomass-urban.htm

Energy from Urban Waste

"…Every large Texas city should carefully evaluate its landfill gas potential. Why? Because what used to be known as"the dump" has become one of America's most cost-effective and reliable energy resources.
The number of Texas landfill gas-to-energy projects have been steadily increasing in recent years as landfills are being tapped for heat, electricity and renewable motor fuel…."
(*Read entire article at link above*)

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http://uk.ibtimes.com/articles/20110421/waste-recycling-group-grows-crops-biofuel-landfills.htm

Waste Recycling Group grows crops for biofuel on landfills

By Emily Smoucha | 21 April 2011, 10:21 BST

"….A waste firm is turning its old landfill sites into areas for growing biofuel crops. The **Waste Recycling Group** (WRG) has begun planting grasses for **biofuel** on 14 of its former **landfill** sites around England…"
(*Read entire article at link above*)

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http://www.renewable-energy-news.info/nc-startup-to-reclaim-landfill-trash-for-biofuels/

NC Startup to Reclaim Landfill Trash for Biofuels

17 May 2010

Trailblazing Company to Recycle & Reclaim Landfill Trash for Waste to Fuel Facility-

(*Read entire article at link above*)

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http://www.gizmag.com/envion-plastic-waste-to-oil-generator/12902/

Envion Oil Generator turns plastic waste into oil

By Paul Ridden

17:12 September 21, 2009

"…The ground-breaking Envion Oil Generator (EOG) gave its first public performance at the Montgomery County Solid Waste Transfer Station in Derwood, Maryland recently. The EOG can be fed almost any petroleum-based waste plastic and will convert it into synthetic light to medium oil for less than USD$10 per barrel. As with crude oil, the synthetic oil can then be processed into commercial fuels or even back into plastic…."

(*Read entire article at link above*)

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HOPE FOR OREGON AND THE PACIFIC WEST COAST

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Earthfix

http://earthfix.opb.org/energy/article/huge-oregon-wind-farm-starts-making-power-for-so-c/

Huge Oregon Wind Farm Starts Making Power for So. Cal.

Sept. 24, 2012 | OPB – By April Baer

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The World

http://theworldlink.com/news/local/kitzhaber-has-a-new-green-plan/article_8cbd1c24-0ad5-51c2-930e-9bd2b6f3d39c.html

Kitzhaber has a new green plan

The Associated Press The World | Posted: Monday, March 5, 2012

"…PORTLAND — Gov. John Kitzhaber has a new 10-year plan he hopes will be able to reactivate green energy in Oregon.

Despite the state's embrace of wind and solar companies, they're not making much of a contribution to the state's energy needs.

The Columbia Plateau is now draped in wind turbines, but they supply only 3 percent of Oregon's electricity. Solar and geothermal make a small contribution. Existing hydro-electricity is a big contributor, but fossil fuel plants still contribute half the state's electricity.

The governor hopes his new plan will change those numbers, The Oregonian reports in Sunday's newspaper….."

(*Read entire article at link above*)

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http://www.rbf.org/post/clean-economy-study-reveals-substantial-job-creation-potential-west-coast

Clean Economy Study Reveals Substantial Job Creation Potential for the West Coast

"…Clean economic growth has the potential to raise GDP contributions to $142.7 billion in the United States' West Coast region by 2020, growing clean economy jobs by 200 percent over current numbers, according to a report published by Globe Advisors with RBF grantee the Center for Climate Strategies. The report, "*The West Coast Clean Economy: Opportunities for Investment & Accelerated Job Creation*," was commissioned by the Pacific Coast Collaborative. It identifies three key sectors with the highest potential for job growth: energy efficiency and green building, environmental protection and resource management, and clean transportation…"
(*Read more, download report, at link above*)

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http://www.climatestrategies.us/library/library/view/972

The West Coast Clean Economy, Opportunities for Investment & Accelerated Job Creation

March 2012.
A report commissioned by the Pacific Coast Collaborative; prepared by Globe Advisors and The Center for Climate Strategies.
(*View report at link above*)

Pacific Environment
http://pacificenvironment.org/pacific-environment-applauds-californias-decision-to-reject-fossil-fuels

Regulators Say No to More Fossil Fuel Power Generation in California

Thursday, April 19, 2012

"…After determining that the existing electricity supply can meet the state's system needs through the year 2020, the California Public Utilities Commission (CPUC) voted unanimously today to defer any new procurement of fossil fuel generation. This ruling establishes for most of the state, that California's long-term energy needs do not require building more fossil fuel infrastructure, which contributes to global warming.

"What this decision is really about is our society saying no to dirty fossil fuels, and yes to clean energy," said Alex Levinson, Executive Director of Pacific Environment. "The decision affirms California's critical leadership in building the clean energy economy of the future."

The CPUC decision found there is clear evidence that "additional generation is not needed by 2020." The decision further explains that "[w]hile the focus of this proceeding extends out to 2020, it is important to note that the record similarly does not support a finding of need for additional generation beyond 2020. Accordingly, it is also reasonable to defer procurement of generation for any estimated need after 2020."…"
(*Read more at link above*)

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http://www.sustainablebusiness.com/index.cfm/go/news.display/id/23652?utm_source=Sailthru&utm_medium=email&utm_term=Enewsletter&utm_campaign=newsletter

California Governor Issues Sweeping Order to Green Government

Sustainable Business.com News – 04/27/2012

"…California Governor Jerry Brown issued a sweeping executive order that will make the state's government a model for green building.

50% of new state buildings beginning design in 2020 must be Zero Net Energy, and all new state buildings and major renovations that begin design after 2025 must be Zero Net Energy.

State agencies shall also take measures toward achieving Zero Net Energy for 50% of the square footage of existing state-owned building area by 2025.

- Any proposed new state building or major renovation larger than 10,000 square feet has to generate its power onsite using solar or wind, if economically feasible.
- New state buildings and major renovations larger than 10,000 square feet have to obtain LEED Silver certification or higher.

All state facilities have to cut power bought from the grid 20% (below a 2003 baseline) by 2018…."
(*Read entire article – Link to the Executive Order at link above*)

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http://governor.oregon.gov/Gov/media_room/speeches/s2012/future_energy_conference_042512.shtml

Oregon Governor Kitzhaber delivers keynote address to Future Energy Conference

Future Energy Conference - April 25, 2012

"…Today over 508,000 Pacific Coast residents from California to British Columbia are cashing "green job" paychecks every week. We therefore reject the myth that jobs and the environment are in conflict – because our own experience and hard data shows otherwise. We know what other regions have yet to learn:

- That the cleanest form of energy is the energy we don't use and that there is tremendous economic potential in significantly scaling up investment in energy efficiency and conservation;
- That the real potential of our extraordinary natural assets lies not in their exploitation, but in their restoration; and
- That the global market is hungry for technologies, products and services that get things done more efficiently and at a lower cost — the keys to a clean economy.

Here are the facts: Job creation rates in the clean economy are well above those for other shrinking sectors of the economy. They pay better. And they have been more resilient to the downturn of the Great Recession.

And now the new West Coast Clean Economy Opportunity Study – commissioned by the Pacific Coast Collaborative – estimates that the regional clean economy could triple in size to $147 billion by 2020.

Our success in meeting that goal will depend on our willingness to develop regional partnerships; and our willingness to pioneer ahead and embrace change – tempered with a dash of west coast stubbornness to stay the course no matter which way political winds blow….."

"….The goal is clear: to prioritize and act on initiatives to reduce our dependence on carbon-intensive fuels and foreign oil; to develop home-grown renewable energy resources; to mitigate greenhouse gas emissions; to improve energy efficiency and create local jobs; and to boost Oregon's economy through investment and innovation…."
(*Read entire speech at link above*)

SUCCESSFUL RENEWABLE ENERGY PROGRAMS ARE ALREADY UNDERWAY IN OTHER COUNTRIES

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http://www.fwtm.freiburg.de/servlet/PB/menu/1182949_l2/index.html

Freiburg Green City

The City of Freiburg is internationally well known for its environmental approach and its extensive use of solar energy and other renewable sources. Freiburg Green City can share experiences gained over many years and showcase a multitude of effective technical and organizational solutions related to sustainable energy management.

Freiburg Green City – Approaches to Sustainability Brochure (PDF, 3 MB)
http://www.freiburg.de/servlet/PB/show/1199617_l2/GreenCity_E.pdf

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http://gcaptain.com/worlds-largest-solar-powered/?46077

World's Largest Solar Powered Ship Completes Record-Breaking Circumnavigation

By gCaptain Staff On May 7, 2012

"…On Friday the world's largest ship running solely on the power of the sun cruised into Hercule Harbor in Monaco, officially completing the world's first circumnavigation for a 100% solar powered ship…"
(*Read more at link above*)

Grist
http://grist.org/list/india-flips-the-switch-on-worlds-largest-solar-power-plant/

India flips the switch on world's largest solar power plant

By Jess Zimmerman
April 20, 2012

"…The Indian state of Gujarat has built the world's largest solar photovoltaic power plant, a field of solar panels the size of Lower Manhattan. After only 14 months of preparation, they've just switched it on, adding 600 megawatts of power to the grid. That's enough to power a medium-sized city's worth of homes. Thing is HUGE.

The 5,000-acre solar park should help India meet its ambitious plans for moving to sustainable energy. The country aims to be at 15 percent renewables by 2020 — right now it's only at 6 percent. Projects like the Gujarat plant will help by taking advantage of India's intense sunshine…"
(*Read more, view photo, at link above*)

Solar Daily
http://www.solardaily.com/reports/Worlds_largest_solar_thermal_plant_online_999.html

World's largest solar thermal plant online

By Staff Writers
Riyadh, Saudi Arabia (UPI)
Published April 11, 2012

"…The world's largest solar thermal plant has gone into full operation in the Saudi Arabian capital of Riyadh after a six-month trial, officials said.

The $4.7 million solar heating plant was designed by the Austrian research institute AEE INTEC and manufactured by Austria's GREENoneTEC company, China's Xinhua News Agency reported Wednesday…"
(*Read more at link above*)

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http://www.youtube.com/watch?v=G6MxmkKRfkY

Offshore Wind Farm – Giving Bremerhaven a Tail Wind | *Made in Germany:*

Apr 20, 2011 - deutschewelleenglish
Report by Marion Hütter

German harbors are counting on offshore wind farms. The Bremen Wind Energy Agency estimates that wind turbines will be installed at sea producing ten gigawatts of power by 2020 – the same amount of energy as 15 power plants. Because the giant structures are so hard to transport, they'll be manufactured right there on the coast. That's a shot in the arm for the economically underdeveloped region.
(*View story at link above*)

Solar Power Tower – Seville, Spain:

Uploaded by justinsolarguy on Mar 21, 2011

Part 1 of 2
http://www.youtube.com/watch?v=2wM2Vqw1YjY (7:59 min)
Part 2 of 2
http://www.youtube.com/watch?v=yPrsyxEyxgA (3:17 min)

http://www.engadget.com/2007/05/04/spanish-solar-tower-could-eventually-power-an-entire-city/

Spanish Solar Tower Could Eventually Power an Entire City

By Darren Murph posted May 4th 2007

"…Just last month we witnessed a gigantic skyscraper / solar tower hybrid that generates a whopping 390-kilowatts of energy, but even that looks like child's play compared to the 40-story solar power plant that resides in Spain. The expansive system consists of a towering concrete building, a field of 600 (and growing) sun-tracking mirrors that are each 120-square meters in size, and a receiver that converts concentrated solar energy from the heliostats into steam that eventually drives the turbines. Currently, only one field of mirrors is up and running, but even that produces enough power to energize 6,000 homes, and the creators are hoping to see the entire population of Seville (600,000 folks) taken care of solely from sunlight. So if you're eager to see what's likely the greenest solar power plant currently operating, be sure to slip on some shades, tag the read link, and peep the video…."
(*Read more, link to videos, at link above*)

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http://www.youtube.com/watch?v=m9e1pou-db4

Eco Tech: Powering Up Malmo, Sweeden with Renewable Energy

7:24 min

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The Pearl River Tower in China is slated to be completed in 2012 and is being designed to produce more energy than it consumes – .
http://www.som.com/content.cfm/pearl_river_tower

[Great Photo's of this project at the link below]
http://www.greendiary.com/entry/pearl-river-tower-china-to-flaunt-world-s-greenest-skyscraper/

Pearl River Tower: China to flaunt world's greenest skyscraper

Posted by: Aditi Justa | Mar 30 2010

"…We at Greendiary have introduced you to many skyscrapers in the past, where some boosted their unparallel beauty, the others exhibited their extraordinary design and sustainable features. This time around, I bring to you a skyscraper that could be tagged as the world's greenest skyscraper. The "zero energy" Pearl River Tower erected at the in Guangzhou, China is designed the architectural firm Skidmore, Owings and Merrill. The structure makes use of the best sustainable technology, passive wind and solar design, and innovative structural techniques in order to get a near zero energy tag…."
(*Read more at link above*)

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The New York Times
http://www.nytimes.com/2010/08/10/science/earth/10portugal.html

Beyond Fossil Fuels

Portugal Gives Itself a Clean-Energy Makeover

By ELISABETH ROSENTHAL
Published: August 9, 2010

"…LISBON — Five years ago, the leaders of this sun-scorched, wind-swept nation made a bet: To reduce Portugal's dependence on imported fossil fuels, they embarked on an array of ambitious renewable energy projects — primarily harnessing the country's wind and hydropower, but also its sunlight and ocean waves.

Today, Lisbon's trendy bars, Porto's factories and the Algarve's glamorous resorts are powered substantially by clean energy. Nearly 45 percent of the electricity in Portugal's grid will come from renewable sources this year, up from 17 percent just five years ago.

"…"The experience of Portugal shows that it is possible to make these changes in a very short time."…"

"…Portugal was well poised to be a guinea pig because it has large untapped resources of wind and river power, the two most cost-effective renewable sources. Government officials say the energy transformation required no increase in taxes or public debt, precisely because the new sources of electricity, which require no fuel and produce no emissions, replaced electricity previously produced by buying and burning imported natural gas, coal and oil. By 2014 the renewable energy program will allow Portugal to fully close at least two conventional power plants and reduce the operation of others…."

"…So far the program has placed no stress on the national budget" and has not created government debt, said Shinji Fujino, head of the International Energy Agency's country study division…"
(*Read Entire Article at Link Above.* - A version of this article appeared in print on August 10, 2010, on page A1 of the New York edition.)

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The New York Times
http://www.nytimes.com/2010/12/11/science/earth/11fossil.html?_r=1

Beyond Fossil Fuels

Using Waste, Swedish City Cuts Its Fossil Fuel Use

By ELISABETH ROSENTHAL
Published: December 10, 2010

"…KRISTIANSTAD, Sweden — When this city vowed a decade ago to wean itself from fossil fuels, it was a lofty aspiration, like zero deaths from traffic accidents or the elimination of childhood obesity.

But Kristianstad has already crossed a crucial threshold: the city and surrounding county, with a population of 80,000, essentially use no oil, natural gas or coal to heat homes and businesses, even during the long frigid winters. It is a complete reversal from 20 years ago, when all of their heat came from fossil fuels.

But this area in southern Sweden, best known as the home of Absolut vodka, has not generally substituted solar panels or wind turbines for the traditional fuels it has forsaken. Instead, as befits a region that is an epicenter of farming and food processing, it generates energy from a motley assortment of ingredients like potato peels, manure, used cooking oil, stale cookies and pig intestines…"

"…Once the city fathers got into the habit of harnessing power locally, they saw fuel everywhere: Kristianstad also burns gas emanating from an old landfill and sewage ponds, as well as wood waste from flooring factories and tree prunings…."

"…"It's a much more secure energy supply — we didn't want to buy oil anymore from the Middle East or Norway," said Lennart Erfors, the engineer who is overseeing the transition in this colorful city of 18th-century row houses. "And it has created jobs in the energy sector."…"
(*Read Entire Article at Link Above.* - A version of this article appeared in print on December 11, 2010, on page A1 of the New York edition.)

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Germany's Ursula Sladek shows us how it can be done!!

2011 Goldman Prize Winner – Ursula Sladek –

Watch inspiring 3 minute video at this link: (You'll be glad you did.)

http://goldmanprize.org/2011/europe

In response to Germany's expanded reliance on nuclear energy, Ursula Sladek created her country's first cooperatively-owned renewable power company. She helped formed what would become a 10 year project to take over the local grid, and in a second step, allow people all over Germany to choose safe, reliable, sustainably-produced energy. This project would transform Sladek from a small-town parent trained to be a schoolteacher into the founder and president of one of Europe's first cooperatively-owned green energy companies.

The German government is now aligned with EWS's sustainability ideals, with a goal of deriving **100% of the country's power from renewable sources by 2050.** EWS has grown thanks to growing public support for renewable energy in Germany, and the subsequent measures taken by the government, which has encouraged investment in renewable energy projects throughout the country.

WAY TO GO URSULA SLADEK!! Thank you for letting us know "We the People" CAN do what it takes to CHANGE our world for the better!

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Solar Energy
http://www.gstriatum.com/solarenergy/2009/05/a-100-renewable-energized-city/

A 100% Renewable Energized City

May 2009

The German town of Dardesheim has become the first in the world feeded one hundred percent on renewable energies, installed Aeolian turbines near the town and photovoltaic solar panels installed in the tile roofs of these houses, instead of farms as it happens in other places or cities, for example, the case of Ontario, in Canada.

In this case, according to the Web "Renewable Energies", in this town there are 4,000 houses that need energy with a cost among 120 and 130 million kilowatts/hour (kWh).

According to the local authorities this model of power consumption "is completely possible and if the idea works, it will also be tried in other small localities of the zone".

In addition, Dardesheim wants to attract tourists interested in the sector of renewable energies and and they will open an information center and they will install a turbine with an observation platform.

One of the aeolian turbines made by the German company Enercon and it is considered the most powerful of the world, the "E-112", is installed in this locality. It is a gigantic turbine designed to produce 6 megawatts per hour (until now the secured maximum was 4-5 MW/h), enough energy for the consumption of 4,000 homes.

The name "E-112" comes from the diameter of its rotor: 112 meters. It has an innovating mechanism, without gears, that allow it to work without oil. The shape of the shovels has been designed to avoid the noise emission.

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City of *Dardesheim, Germany* - Status of the Dardesheim Renewable Energy Projects (2012):
http://www.go100percent.org/cms/fileadmin/media_upload/projects_files/europe/dardesheim_RenewableEnergyProjects.pdf

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http://energyselfreliantstates.org/content/distributed-renewable-energy-3rd-industrial-revolution

Distributed Renewable Energy as the 3rd Industrial Revolution

Fri, January 20, 2012 – John Farrell

"I just came across an interesting interview that radio host Diane Rehm did with Jeremy Rifkin, author of *The Third Industrial Revolution*. The excerpts below lay out his vision for an energy future that is decentralized and democratized. (He also notes that this vision has just emerged in the past two to four years, but we've been around since 1974…).

The book is organized around five pillars of the third industrial revolution:
Pillar one, renewable energy. Pillar two, your buildings become your own power plants. Pillar three, you have to store it with hydrogen. And then Pillar four…the internet communication revolution completely merges with new distributing energies to create a nervous system…Pillar five is electric plug-in transport…

when distributed Internet communication starts to organize distributed energies, we have a very powerful third industrial revolution that could change everything…

You can find some renewable energy in every square inch of the world. So how do we collect them? … If renewable energies are found in every square inch of the world in some frequency or proportion, why would we only collect them in a few central points? …

[it] jump starts the European economy, that's the idea. Millions and millions and millions of jobs. Thousands of small and medium-sized enterprises have to convert 190 million buildings to power plants over the next 40 years…
That's the vision: a decentralized energy system can be democratized with local ownership, spreading the production of energy and the economic benefits as widely as the renewable energy resource itself."

Source:
The Diane Rehm Show

Publication Date:
Tue, September 27, 2011 (All day)'

Article Link:
Jeremy Rifkin: "The Third Industrial Revolution"

(More info at link above)

Visit www.go100percent.org for additional information on renewable energy projects across the globe

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Citizens Against LNG
Petition Sheets

-----PROTECT COOS, DOUGLAS, JACKSON, & KLAMATH COUNTIES & THE STATE OF OREGON-----

STOP LNG TERMINAL & PACIFIC CONNECTOR GAS PIPELINE

PETITION TO PREVENT LNG EXPORT TERMINAL & STORAGE TANK FACILITY; PASSAGE OF LNG TRANSPORT VESSELS THROUGH THE COOS BAY HARBOR & CHANNEL; AND TO STOP THE 230 MILE, 36 INCH PACIFIC CONNECTOR GAS PIPELINE TO THE CALIFORNIA BORDER.

To State of Oregon Governor John Kitzhaber and to his appointed Port of Coos Bay Commissioners; to the Commissioners of Coos, Douglas, Jackson, & Klamath County Oregon; to those elected by the people of Oregon who represent the people of Oregon in any state or federal office; and to any person or persons elected by the people or appointed to represent the public trust and interest of the citizens of the State of Oregon.

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Jody McCaffree	Jody McCaffree	PO Box 1113 North Bend, OR 97459	
2	Lydia Delgado	Lyd Delgado	555 Douglas Bandon OR 97411	
3	JC Williams	JC Williams	66642 NB E. Bay Rd 97459	
4	Chris Morrow	Christina Morrow	633 Shorepines HTS. Coos Bay, Or. 97420	
5	Dana Gaab	Dana Gaab	Box 991 North Bend, Or 97459	
6	Dawn Coburn	Dawn Coburn	25510 SW Canyon Creek Rd #2101 Wilsonville, OR 97070	
7	MICHAEL HANCOCK	Michael Hancock	65472 E. BAY RD NORTH BEND, OR 97459	
8	LINDA E. MORRIS	Linda E. Morris	685 ELROD AVE CS BY OR 97420	
9	Camby Collier	Camby Collier	POB 181 90768 Travis, Coos Bay, OR 97420	
10	Rebecca Walker	Rebecca Walker	1055 E Central Ave. Sutherlin Or. 97479	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Janet C. Stoffel	Janet C. Stoffel	62590 Olive Barbeuld. Coos Bay OR	
2	Curt Clay		POB 822 CB 97420	
3	Claudia Turner	Claudia Turner	91498 Myrtle Ln Coquille, OR	
4	CHARLES W. TURNER	Charles W. Turner	91498 MYRTLE LN. COQUILLE OR	
5	Joyce Fletcher	Joyce Fletcher	2064 Marion St. Apt D North Bend, Or 97459	
6	C Jones	Candy Jones	NB, OR	
7	Tom Greaves	Tom Greaves	155 Mill CB	
8		Angie Jonson	1381 Central Ave. Coos Bay 97420	
9	Sarah Brunnier	Sarah Brunnier	935 S. 11th St., B Coos Bay, OR 97420	
10	DAVID A OSIER		3490 BRUSSELS ST. N.B. OR	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Leslie Dairy P. - II		63677 N Olin Rd Coos Bay Or.	S
2	Elizabeth A Coleman	Elizabeth T Coleman	P.O. Box 3354 CB OR 97420	S
3	Joseph Coleman	Joseph Colm	P.O. Box 3354 C.B, OR 97420	
4	Marcus Sorli E	Marcus Sorli	PO BOX 363 Ethel, WA.	3
5	anthony Hajek	anthony Hajek	1530 Newmark Ave, Apt A Coos Bay	54
6	Jeanine Miller	Jeanine Miller	93346 N. Park Ln. Coos Bay	54
7	Ken Silva	Ken Silva	Pigeon Pt	54
8	Russell Tupac	Russ Tupa	90563 Cape Arago Hwy	54
9	Cherilyn Tupac	Cherilyn Tupac	90563 Cape Arago Hwy	54
10	Jeff Post	Jeff W. Post	91454 Spaw Ln. Cs by OR	E-mai 541

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	CAROL SANDERS	Carol Sanders	664 S. Empire	
2	JUDY WAGNER	Judy Wagner	2465 TROY LN. N.B.	
3	KAREN GOETTE	Karen Goette	93649 Bay Park Ln CBay	
4	HUIE D. KNIGHT JR		99338 LONE PINE LN. M.P.	
5	Wm B Spellman	Wm B. Spellman	694 S. Wasson C.B. OR	
6	Mary-Margaret Stockert	Mary-Margaret Stockert	500 Edwards Ave, CB, OR	
7	William Crombie	William Crombie	500 Edwards Ave., CB, OR	
8	V. Sue Pearson	V. Sue Pearson	63715 Flanagan Rd. CB	
9	Len Milbyer	Len Milbyer	1405 lindberg ave. CB OR	
10	Kevin Bowman	Kevin Bowman	PO Box 5766 Charleston OR 97420	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Dan Stenberg		CTMS	
2	Corena Perry		Bandon OR 97411	
3	Lisa Fisher		342 S. Maple St.	
4	Karen Wright		342 S. Maple St.	
5	Mike Detwiler		92723 Highland Lane	
6	LINDA L PINCHER		395 BUSHNELL DR. WINSTON, OR 97496	
7	DEBORAH MARTIN		825 A. St. MYRTLE POINT, OR 97458	
8		MARYNETT DAVIS	135 Sp $ Camanna St.	
9	Sandy Thomson	S Thomson	879 S Maple	
10	Sondra Gomez	SONDRA Gomez	879 S. Maple	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Anna-Marie Slate	Anna-Marie Slate	827 S. 5th St. Apt. #7 CB OR 97420	
2	Sherri Ross	Sherri L. Ross	64218 Braley Rd CB OR 97420	
3	Tony Ross	Tony Ross	" " "	
4	DAVE HOLMES		→ Barklow Ln. 91334 BARRON	
5	Charity Lewis		241 S. Shaveman apt C-1 CBS	
6	Woody Stokes Jr	Woody Stokes JR	250 S. Marple #10 Coos Bay	
7	Austin Re	Austin Rearyhow	245 S. Shoreman apt G1	
8	Sarah Lusk	S Lusk	OIMB	
9	Thomas Kirkland	Thomas Kirkland		
10	Jessica Butt	Jessica Butt	OIMB	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Clarence Adams	Clarence Adams	2039 Ireland Rd Winston	
2	EUGENE Scott	Eugene Scott	1909 Richardson Myrtle Ck.	
3	Richard Kremer	Richard Kremer	191 Weigle Rd. M. C	
4	Sandra Kremer	Sandra Kremer	PO Box 713 191 Weigle Rd., Myrtle Creek	
5	Diane E. Phillips	Diane E. Phillips	PO Box 179 1746 Quines Ck Rd, Azale	
6	Madalyn Dixon	Madalyn Dixon	Box 753 Canyonville OR 97417	
7	Michael DIXON	Michael Dixon	Box 753 Canyonville OR 97417	
8	Jenny Council	Jenny Council	886 Raven Lane, Lookingglass 97471	
9	Bill Gow	Bill Gow	4993 Clarks Branch Rd. Roseburg, OR. 97470	
10	M.A. HANSEN	M.A. Hansen	548 W Hickory St. & 32404 Bilger Creek Rd	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Joan Dahlman	Joan Dahlman	344 Honey Run Ln. Winston	
2	James Dahlman	James E. DahlMan	344 Honey Run Ln, Winston	
3	Louis Dykstra	Louis Dykstra	984 Wagontire M.C.	
4	John Roberts	John Roberts	2525 Old Ferry Rd. Shady Cove 97539	
5	Lynn H. Quam	Lynn H. Quam	3150 Olalla Rd, Winston	
6	FRANK C Adams	Frank C Adams	1731 Ireland Rd Winston OR 97496	
7	Raynor L Clack	Raynor L Clack	5589 N Myrtle Myrtle Creek. OR. 97457	
8	Calvin D. Clack	Calvin D. Clack	660 Bilger rd Myrtle Creek OR 97457	
9	Ruben Escalera	Ruben Escalera	203 Buck Board Ln Myrtle Creek 97457	
10	Laura Escalera	Laura Escalera	203 Buckboard Ln. Myrtle Creek, OR. 97457	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Lesley Adams	Lesley Adams	P.O. Box 533 Ashland OR 97520	
2	ANNE TAGGART TUNZI	Anne Taggart Tunzi	5629 N. Myrtle Rd. Myrtle Creek OR 97457	
3	JONATHAN HANSON	Jonathan Hanson	62890 OLIVE BARBER RD. COOS BAY, OR 97420	
4	~~MA Rohrer~~	~~MA Rohrer~~	~~68345 Wildwood Road~~ 93558 Hollow Stump North Bend OR 97459	
5	MA Rohrer	MA Rohrer	93558 Hollow Stump Lane North Bend OR 97459	
6	BILL ROHRER	Bill Rohrer	93558 HOLLOW STUMP LN. NORTH BEND OR. 97459	
7	RONNIE HERNE	Ronnie Herne	62650 FAIRVIEW ROAD COQUILLE OREGON 97423	
8	JAYE BELL	Jaye Bell	62650 FAIRVIEW ROAD COQUILLE, OREGON 97423	
9	GENE LAROCHELLE	Gene LaRochelle	1148 CALIFORNIA AVE COOS BAY, OR 97420	
10	WILLARD L. McCAFFREE	Willard L McCaffree	2650 CEDAR ST. NORTH BEND, OR 97459	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	David Midcap	D d M l p	148 S wasson	
2	Terri D Richter	Terri D Richter	64710-A Washington Rd. CB.	
3	Richard F. Kuhlin	Richard F. Kuhlin	555 Delaware St. N.B. 9745	
4	PETER S RYAN	Peter S Ryan	96078 Dean Mtn NB 97459	
5	VERNE HERZ	Verne Herz	525 SO. MAPLE ST. COOS BAY OR 97420	
6	Mary Thegg	Mary R Thegg	1152 S.W. Blvd	
7	BETSEY Fleming	BF	PO Box 3566, Coos Bay, OR 97420	
8	MATTHEW MURRAY	Matthew G Murray	277 S. Empire Blvd. Coos Bay OR 97420	
9	DEBRA WEST	Debra L West	507 Clark St CBOR 9754	
10	Heath Koch	Heath Koch	Grants Pass	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	PAULA HOEHN	Paula Hoehn	63021 CROWN POINT Rd, COOS BAY, OR 97420	
2	William HOEHN	William Hoehn	63021 CROWN POINT Rd. COOS BAY OR. 97420	
3	Cathy Howard	Cathy Howard	1962 Myrtlest. North Bend ORE 97459	
4	Doug Skone	Doug Skone	PO Box 5495 Charleston OR 9742	
5	Patricia Parker	Patricia Parker	94759 North Way Lane North Bend, OR 97459	
6	ED ONEIL		LAKESIDE	
7	Theodore Phillip Scheirman		93977 Sterncrest CB OR	
8	Barbara Scheirman		93977 Sterncrest C.B.	
9	Roselyn Cohen		59568 Fairview Rd COQUILLE	
10	Alma Chavez-Tapia		64579 E. Bay Rd North Bend 97459	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Gwen O'Hara		1100 Bellview Dr NW Grants Pass	
2	MARJORIE SHAPIRO	Marjorie Shapiro	350 Pearl St Eugene	
3	Randy Jorgen	Randy Jorgen	NC-64 2802 Moab UT 84532	
4	DON JOHNSON		GOLD CANYON, AZ	
5	BRAD SEISER	Brad Seiser	10603 NORTHGATE DR PASO CEDRO, CA 96073	
6	FRAN WHITE	Fran White	643 Shorepines Hts Coos Bay OR 97420	
7	Tom ATKINS	Thomas Atkins	40374 High St Cherry Valley CA	
8	JIM WHITE		643 SHOREPINES HGTS COOS BAY OR 97420	
9	Roy Byerly	Byerly	69262 Wildwood Rd N.B., OR 97459	
10	Knute Nemeth		PO 5775 Charleston OR 97420	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	John Schlosinger		92673 Heather Lane Coos Bay OR.	
2	John Thurman		91476 myrtle lane Coq.	
3	Julia Braun		695 SW 8th St. Bandon 97411	
4	Ronny Smith		10119 WRIGHT AVE, Klamath falls OR 97603	
5	STUART MITCHELL		1851 LINCOLN ST. NORTH BEND 97459	
6	Diris D. Murphy		1379 Dakota Ave., Coos Bay OR 97420	
7	L. Downer		836 Newmark N.B 97459	
8	CLARENCE DOWNER		836 Newmark N.B 97459	
9	Candace K. Chatt		91189 Cape Arago Hwy CB 97420	
10	JOHN T. CHATT		91189 Cape Arago Hwy Coos Bay 97420	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Holly Stamper	Holly Stamper	97420 90692 Wiltshire Ln Charleston	
2	Sharon Cunningham	Sharon Cunningham	64586 E. Bay Rd Nor Bend	
3	EDWARD G. PARKER		Hop Patch Spring Rd	
			60290 Mountain Center CA	
4	Jimmy Garrett	JIMMY GARRETT	Po Box 5666 Charleston	
5	EUGENE O'ROURKE		1166 WINSOR NORTH BEND	
6	Matt Christensen	MATT CHRISTENSEN	1609 N. 10TH CB	
7	MIKE PARADISE		524 NO. AMANDA ST Ridgecrest CA.	
8	Lydia Delgado	Lydia Delgado	555 Douglas Ave Bandon OR 97411	
9	Vicki Bunn-Cohen	Vicki Bunn-Cohen	86510 Lower 4-Mile Ln	
10	Stephen Bicknell	Stephen Bicknell	91346 BACKLOW LN	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Teska Jinks	Teska Jinks	313 South Empire Blvd	5
2	Jason Youmans	Jason Youmans	62293 Crown Pt. Rd Millicoma	5
3	Roger Doll	Roger H Doll	5116 Sandy Creek 97459	5
4	James W. Akins	James W. Akins	332 Oak St. Phoenix OR 9755	ji
5	Shelley Akins	Shelley Akins	332 Oak St. Phoenix, OR 975	35
6	DALE CANDLE		533 LAKESHORE COOS BAY 97420	DA
7	Alice Swartz	Alice Swartz	2242 Sheridan Ave	54
8	Paul Merz	Paul Merz	POB 5630 Charleston OR	54
9	Gunter Volpel	Gunter Volpel	90876 Libby Ln. Coos Bay	54
10	Christian Volpel	Christian Volpel	90876 Libby Ln Coos Bay	54

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	CECECIA METZ	Cecelia Metz	3696 Broadway # 256 North Bend, OR 97420	
2	Lauri Archer	Lauri Archer	3696 Broadway #161 North Bend OR 97420	
3	Richanne Jennings	Richanne Jennings	PO Box 422 CB	
4	Jed Morrell	Jed Morrell	3501 NW Harmon Circle Corvallis OR. 97330	
5	Robert. Sucrez	R. Sucrez	636 NE Bond PDX OR 97212	
6	Betty Peterson	Betty C. Peterson	64588 E. Bay Rd. N. Bend 97459	
7	James Husko	James Husko	794 Noble Coosbay 97420	
8	Laura Hines	Laura Hines	980 Oakway C. Bay	
9		Roy Hines	980 Oakway C. Bay	
10		John Smith	363 S Empire Blvd	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Kelly Fleming		Charleston	
2	Arthur Noble		Bandon	
3	Eric V. Anderson II		915 Dunlin St. NE Bandon, OR 97411	
4	David Anchan		375 2nd Bandon OR 97411	
5	Forrest Markham		62909 SW 16th Rd Coos Bay (Charleston) OR 97420	
6	John Anderson		833 First St Coos Bay	
7	~~Carol Anderson~~ Carol Anderson		63541 Jade Street Coos Bay	
8	Ronald Anderson		63541 JADE STREET COOS BAY OR.	
9	Dave Anderson		23 SE 127th AVE, Apt 4 Portland OR 97233	
10			2040 HAYES ST N. B	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Len Otto	Len Otto	37160 SE Lusted Rd. Boring OR 97009	
2	Gloria Otto	Gloria J Otto	37160 SE Lusted Rd Boring, OR 97009	
3	Charles MASON	Charles Mason	661 Noble Ave C/B	
4	Chet Schultz	Chet Schultz	2634 16th St N.B.	
5	Betty Glassman	B. Glassman	1006 Maryland C.B.	
6	Seymour Glassman	S. Glassman	" " "	
7	Dianne Foley	Dianne E Foley	2145 North Lake Road Lakeside	
8	ARNO BOETTCHER		860 DATE	
9	Ilene Mayfield	Ilene Mayfield	90952 Beason Ln Coos Bay, OR	
10	Guthrie Wilson	Guthrie Wilson	63479 Wallace Rd	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Craig Taylor	Craig Taylor	64519 E Bay RD N. Bend OR 97459	
2	ROBERT KAPELA	Robert Kapela	45 NW 101ST PORTLAND, OR 97229	
3	Laird Bryan	Laird Bryan	1233 Winsor North Bend OR 97459	
4	Merle Haney	Merle Haney	66485 Mettman Crk Rd North Bend, Ore	
5	Katherine Sams	[signature]	953 Crysteta Ave GS CO 81501	
6	Catina Biersdorff	Catina Biersdorff	1624 N 17 th Coos Bay OR 97420	
7	ROBERT CARL	Robert Carl	256 N. 13th St Coos Bay 97420	
8	Robin McCreary	[signature]	256 N 13th St, CB OR 97420	
9	ELMER + LINDA Mills	Linda Mills	PO Box 914 WINSTON 63626 BARVIEW	
10	ELMER Mills	Elmer Mills		

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	LeRoy F Johnson	LeRoy F Johnson	171 Rowan St Roseburg, OR 97471	
2	Thomas Plazza	Thomas Plazza	2298 Landers Rosburg LN.	
3	Jason C. Wulff	Jason C. Wulff	4256 Elgarose Rd. Roseburg 97471	
4	Marcus Simone	Marcus Simone	3195 NE Highway 99 Roseburg 97470	
5	Micia Hodges	Micia Hodges	250 umpqua view Dr.	
6	Kristie Mchaughlin	Kristie Mchaughlin	P.O Box 1487 Roseburg	
7	Caleb Otis	Caleb Otis	1407 Upper Cleveland Rpd Rd Roseburg OR 97470	
8	Mike Hall	Mike Hall	400 Miguel ST Roseburg OR 97470	
9	Paul K. Pierce	Paul K. Pierce	5793 Stephens St. Winchester, OR 97495	
10	Richard Ferder	Richard Ferder	612 Laurel Oaks dr Rsbg Or. 97471	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	JEFF REESE		603 S. 11th ST. Coos Bay	54 2
2	Braxton Basch		1149 Oregon Ave	
3	Heather Clonch	Heather Clonch	1125 central ave.	
4	Michael Garza		1625 Kingwood Ave.	541
5	Bill Gow	Bill Gow	4993 Clarks Branch Rd. Roseburg,	
6	M.A. HANSEN	M.A. Hansen	548 W Hickory St. Roseburg, OR	54
7	Janet Lynn Finegan	Janet Lynn Finegan	121 W. River Ridge Ave Roseburg, OR	54
8	CALVIN D. CLACK	Calvin D. Clack	660 Myrtle Rd. MYR. ore.	95
9	Raymond L. Clack	Raymond L Clack	5589 N MYRTLE MYRTLE CREEK, ORE.	97
10	JOHN CLARKE	John Clarke	1102 TWIN OAKS LN WINSTON 97496	54

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	A O'Sullivan	Angela O'Sullivan	1060 W 10th St Coquille	8
2	D T McDonald	Danny T McDonald	66523 E. Bay, Rd N B OR	6
3	Samuel Hanks		1990 Johnson St	5
4	Ron Howell		122 Canyonville OR	5
5	Robert D Fischer	Robert D Fischer	1127 12th St SE Bandon OR 9741	5
6	Carol Fischer	Carol Fischer	P.O. Box 1985 Bandon OR 97411	5
7	Jan Dilley	Jan Dilley	1223 Winsor Ave	5
8	Jonathan Hanson	Jonathan Hanson	62890 Olive Barber Rd, Coos Bay	5
9	Nancy Shinn	Nancy Shinn	1040 E 13th St, Coquille	54
10	George E. Shinn	George E Shinn	1040 E 13th St, Coquille	5

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Anthony Wallace	Anthony Wallace	90985 Matthew Lane	
2	Debbie Wallace	Debbie Wallace	" "	
3	Natasha Wallace	Natasha Wallace	" "	
4	Jack Flitcroft	Flitcroft	766 10th	
5	Pat Flitcroft	Pat Flitcroft	"	
6	Sarah Recken	Sarah Recken	66628 Oriole Rd. North Bend	
7	Thomas Bruce		609 Exchange NB	
8	Jan Wentz		"	
9	Odee Jennings		CB	
10	Guthrie Wilson	Guthrie Wilson	63479 Wallace Rd Coos Bay	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	DAVID JOHNS		86319 LORANE HWY EUG, OR	
2	LINDA AGNETE	Linda Agnete	90931 PIGEON PT. LOOP C.B OR	
3	BRIAN LINDSET	Brian Lindsey	89428 Shore Crest Dr. Florence	
4	Rick Staggenborg		1462 N 10TH CT COOS BAY, OR	
5	Charlene Collier	Charlene Collier	1115 Jumper Coos Bay OR	
6	Cynthia Hall	Cynthia H. Hall	1008 Noble Coos Bay OR	
7	TINA Post	Tina Post	61457 Old Wagon Rd	
8	Crystal Gray	Crystal Gray	337 Ladiki St. Coos OR. Bay	
9	Ron Lovell	Ronald D. Lovell	61986 Old Wagon Rd Coos Bay OR	
10	Judy Lovell	Judy Lovell	61986 Old Wagon Rd. CB	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Brett Claiborne	Brett Claiborne	223 S. 7th Coos Bay, Or 97420	
2	Tammy Bray	Tammy S Bray	61982 Old Wagon Road Coos Bay 97420	
3	John Caughell	John S. Caughell	61982 Old Wagon Rd	
4	Joan Walters	[illegible]	[illegible] Yuba [illegible] CA	
5	Ron Petock	Ron Petock	60687 Catching Slough Rd Coos Bay	
6	F J Petock	F J Petock	60687 Catching Slough Rd	
7	SHARON STURGIS	Sharon Sturgis	91536 CAPE ARAGO COOS BAY, OR 97420	
8	Mary Dean-Fernandez	Mary Dean Fernandez	66607 Quail Rd North Bend OR 97459	
9	Leo P. Fernandez	Leo P Fernandez	66607 Quail Rd North Bend OR 97459	
10	Brent White	Brent White	91320 Baines lane north Bend OR 97459	

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PETITION TO PREVENT LNG EXPORT TERMINAL & STORAGE TANK FACILITY; PASSAGE OF LNG TRANSPORT VESSELS THROUGH THE COOS BAY HARBOR & CHANNEL; AND TO STOP THE 230 MILE, 36 INCH PACIFIC CONNECTOR GAS PIPELINE TO THE CALIFORNIA BORDER.

To State of Oregon Governor John Kitzhaber and to his appointed Port of Coos Bay Commissioners; to the Commissioners of Coos, Douglas, Jackson, & Klamath County Oregon; to those elected by the people of Oregon who represent the people of Oregon in any state or federal office; and to any person or persons elected by the people or appointed to represent the public trust and interest of the citizens of the State of Oregon.

We the undersigned declare that a liquefied natural gas (LNG) export terminal and storage tank facility is not a well conceived or appropriate industry for Oregon and that LNG represents an unacceptable risk to the people of the State of Oregon. For the safety, security, and well being of the citizens of our communities, the citizens and residents of the State of Oregon ask you to immediately take action to stop the LNG export terminal and storage tank facility proposed for the North Spit of Coos Bay and the 230 mile, 36 inch Pacific Connector natural gas pipeline to the California border.

	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Martin J Piker	Martin J Piker	1239 Scott Lane N. Bend OR	
2	Jeff Eberwein Eberwein	Eberwein	555 13th Ct Coos Bay	
3	Tracy Eberwein	Tracy Eberwein	555 13th ct, Coos Bay, OR 97420	
4	Linda Spencer	Linda Spencer	3643 Inland Dr #7 North Bend, Or.	
5	JOAN Lopez	Joan Lopez	3415 OAK ST NORTH BEND, OR 97459	
6	Christina McNair	Christina McNair	675 W. Telegraph Dr Coos Bay OR	
7	Laura Nelson	Laura Nelson	950 N. 9th St. Coos Bay OR	
8	Ron Cellers		67978 Rhoades Rd NB 97459	
9	Lilith M Nix	Lilith Nix	564 S. 6th St Coos Bay OR	
10	David Salley	David Salley	2362 Sherman Ave.	

Please return petition, completed or not, to: **Citizens Against LNG, P.O. Box 1113, North Bend, OR 97459**

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Christina Spence	Christina Spence	864 S 5th St. Apt 2, Coos Bay, OR	
2	Steven McSweeney		PO Box 1045 North Bend OR	
3	Joshua Norberto	Joshua Norberto	341 Spruce Dr. Brookings, OR.	
4	Daiven Carter	Daiven Carter		
5	JEFF POPE		653 Pilger Rd Sutherlin OR	
6	Nicole Roderick	Nicole Roderick	1279 South 10th	
7	Joseph Sicheneder	Joseph Sicheneder	63295 Shinglehouse Sl. Rd. Coos Bay Or. 97420	
8	Brenda Rada	Brenda Rada	93228 Sneddan Ln. Coos Bay, OR	
9	Suzanne Ross	Suzanne Ross	P.O. Box 1536 North Bend, OR 97459	
10	Mary Fortier	Mary Fortier	2512 Oak ST N Bend, OR 97459	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Kyle Bussey	Kyle Bussey	990 S. 11th CB OR	2
2	Carol Denbow	Carol Denbow	66513 Schoolhouse Rd NB	C
3	RICHARD WINDRED	[illegible]	90959 PIGEON POINT LOOP	
4	Cheryl Adams	Cheryl Adams	91222 Cape Arago HWY	C
5	~~Jasmine~~ Davis	Jasmine Davis	91222 Cape Arago HWY	T
6	YASMEEN DAHIR	Yasmeen Dahir	90959 Pigeon Point Loop	5
7	Eva W. Ahuna	Eva W. Ahuna	1434 N. 10th St. C.B.	5
8	George K Ahuna	George K Ahuna	1434 N 10th St CB	5
9	Linda Mitchell	Linda Mitchell	2507 OAK - North Bend	5
10	Thomas C. Mitchell	Thomas Mitchell	2507 Oak North Bend	5

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Rachel Brock	Rachel Brock	CB	
2	Jonathon Turner	Jonathon Turner	CB	
3	DAVID STOREY	David Storey	CB	
4	Monty Hannivold	Monty Hannivold	CB	
5	Dorothy Hannivold	Dorothy Hannivold	CB	
6	Michael L Jennings	Michael Jennings	M.P	
7	Mary G Woods	Mary G Woods	CB	
8	Ed Woods	Ed Woods	CB	
9	DANIEL BAUMANN	Daniel B	Coos Bay, OR 97420	
10	Yvonne allen	Yvonne allen	990 S. 11th S. apt 3 CoosBay	

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	NAME (Print)	SIGNATURE	ADDRESS	PHONE / EMAIL
1	Cindy Walker	Cindy Walker	95041 Stock Slough Ln	5
2	DARRELL SANDERS		664 S. Empire Blvd	5
3	Marian Rogers	Marian Rogers	93583 Lookout Lane #3 CBO	54
4	Jan H Doyle	Jan H Doyle	2668 mereyeloop Coos Bay	97420
5	Italia Rushkar	Italia Rushkar	605 John Ave. C. Bay	4
6	JEFF SANDERS		664 S. EMPIRE BLVD COOS BAY	9
7	Lois von Hippel	Lois von Hippel	2211 Union Ave., North Bend, OR 97420	
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10				

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