Capacity Building Workshop

Theme 1: Commercial Aspects and Opportunities for Storage of CO_2 in Oil & Gas Reservoirs

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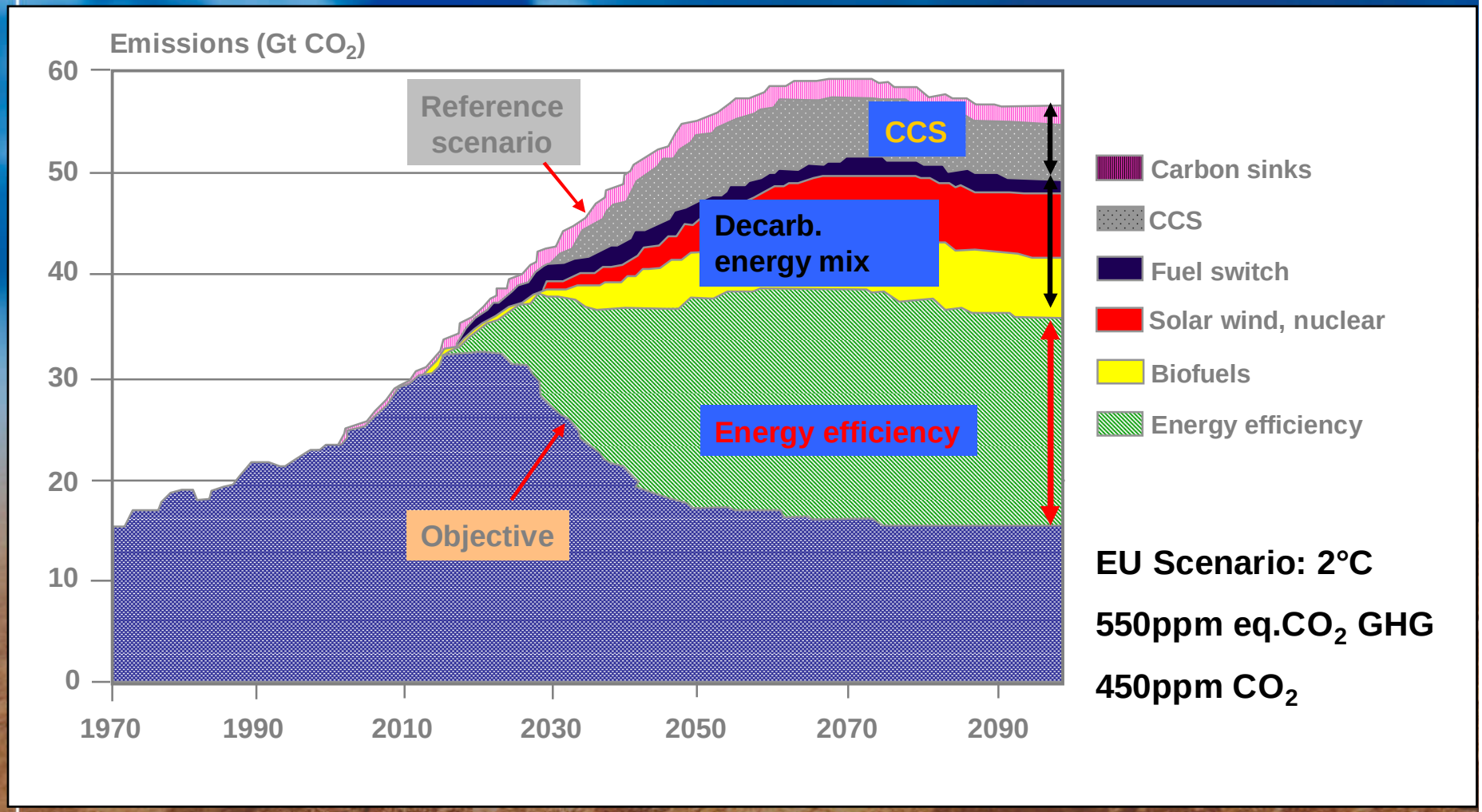
What do we have to do ?



EU Scenario: 2°C

550ppm eq.CO_2 GHG

450ppm CO_2

Source : Commission Européenne

CCS Assurances

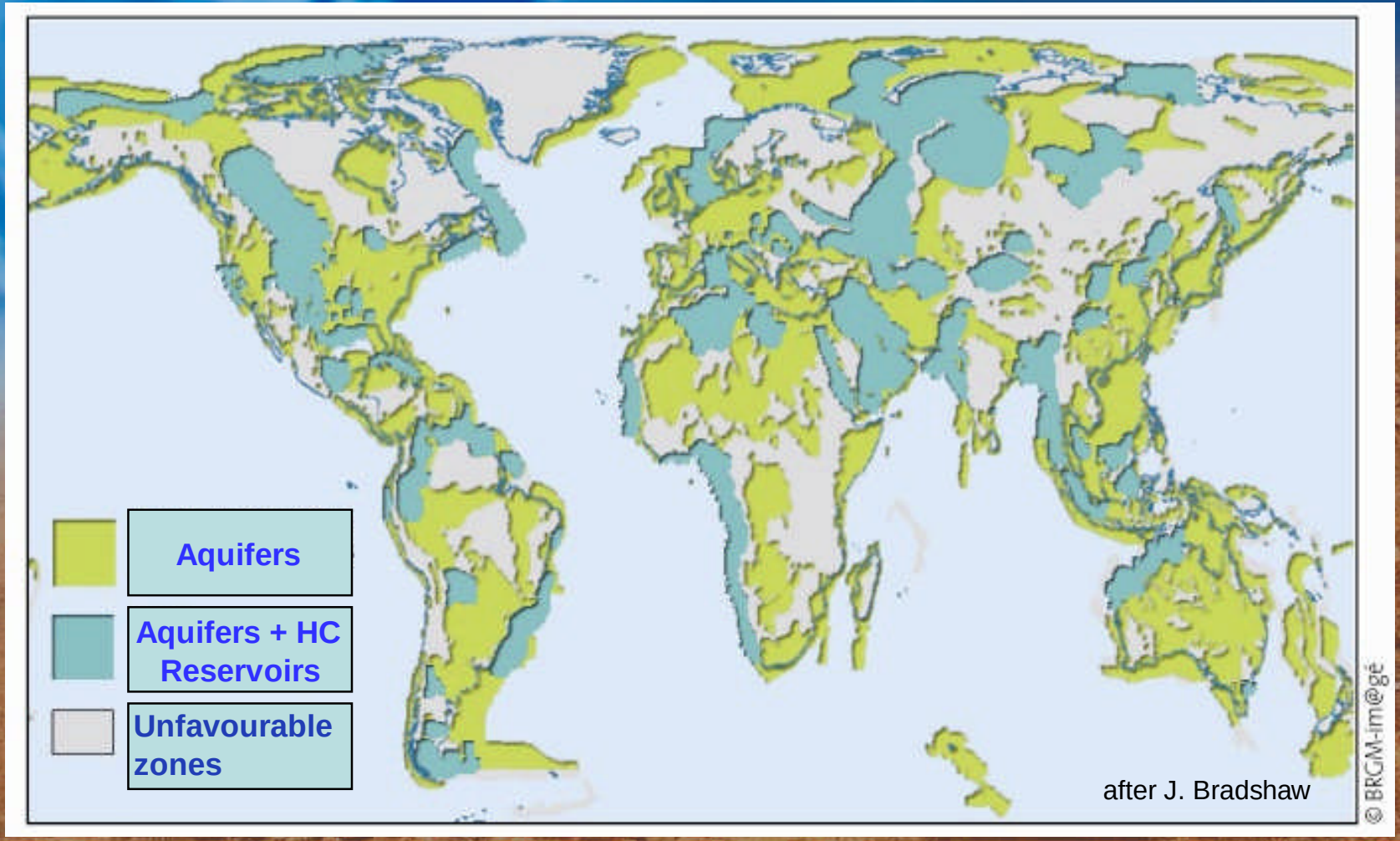
- Technical validity
  - Technical assurance, verifiable and credible (scientists and engineers)
- Policy and legal validity
  - Policy and regulation planning (government)
- Commercial validity
  - Investment decisions (business)
- Environmental validity
  - Identify and establish sustainability of CCS / geological storage (community)

Estimated storage potential

Storage Options	Global Capacity Gt CO_2 *(Years of emissions)*
Depleted Oil & Gas Fields	920 (~40 yrs)
Deep saline aquifers	400 – 10,000 (~15 – 400 yrs)
Unmineable Coal Seams	40 (< 2 yrs)

From IEA

Sedimentary basins worldwide



CO_2 storage in deep saline aquifers

- The largest potential globally (IPCC 2005)
  - Relative potential for various storage types:
    - 1000 Deep saline aquifer storage
    - 100 Oil & gas field use (EOR-EGR) and storage
    - 10 Deep un-mineable coal bed use (ECBM) and storage
    - 1 Mineral sequestration
- But ...
  - Poorly explored
  - Vertical (at least) confinement to be proven
  - Injectivity to be proven
  - Competition with other activities (geothermal, gas storage, ...)

CO_2 storage in "depleted" oil & gas fields

- Estimated potential: 920 Gt CO_2
- Many "depleted" O&G fields include:
  - Depleted fields
  - Producing fields
  - Discovered – not producing
  - Undiscovered fields – “yet to be found”
- But ...
  - Is there enough big fields (> 100 Mt CO_2 capacity) ?
  - When is this capacity really available ? Will be the situation different in 10 years ?
  - Decommissioning issue

CO_2 storage in oil fields

Pros

- Incremental oil recovery
- Known seal/enclosure/ trap to oil (gas?)
- Existing injection facilities
- Well characterised (knowledge of reservoir architecture and dynamic performance)
- Modest pressure changes during lifetime

Cons

- Low incremental rates
- Large volumes of water and CO2 produced
- Significant additional CO2 generated to power recycling
- Facilities and well upgrades required
- Limited window of opportunity prior to cessation of production
- Abandoned wells may compromise trap

CO_2 storage in gas fields

Pros

- Known physical trap and seal to hydrocarbon gas (at least originally)
- Well characterised (knowledge of reservoir architecture and dynamic performance)
- Known capacity (volume previously occupied by produced gas)
- Known injectivity (inferred from productivity)
- Existing infrastructure

Cons

- Significant pressure drop may have compromised trap
- Abandoned wells may compromise trap
- CO2 expansion required at base of well (CO2 delivered in dense phase but initially stored in gas phase)
- Aquifer influx may limit capacity/injection rate
- Facilities and well upgrades required

Perspectives from an oil & gas company: an example

How Carbon Sequestration is considered in PETROBRAS?

Petrobras 2020 Strategic Plan (Courtesy Paulo Cunha)

- To invest in research, development and demonstration of technologies for climate change mitigation and reduction of the carbon risk of our activities, including technologies of carbon sequestration.
- To invest in research to improve the climate change global themes comprehension, providing scientific support to the decisive processes, allowing the anticipation of adaptation measures through Petrobras activities potential impacts and vulnerabilities.
- To develop methodology to evaluate the environmental performance of our products on their life cycle.

Some definitions

- Geological storage of CO_2 = a CO_2 mitigation option
- Geological storage of CO_2 = currently not regulated
- Enhanced hydrocarbon recovery = production method
- Enhanced hydrocarbon recovery = well regulated
- New concepts:
  - "Clean oil recovery" as the combination of CO_2-EOR and long-term storage of CO_2
  - "Clean gas recovery" as EGR or re-injection of CO_2 from natural processes