Financing model for power plants with CCS

Addressing Barriers to Carbon Capture and Storage in Developing Countries

CSLF Financing Task Force Meeting, Beijing

September 19 2011

Natalia Kulichenko

World Bank

Background

Objective was to build a levelizedcost of electricity (LCOE) model to investigate how:

- **Coal prices**
- **CO2prices**
- **EOR/ECBM revenues**
- **Level of concessional financing**
- **Affect LCOE of coal plants with CCS**

Scenarios

- **Coal price**
  - **Low 1$/mmbtu**
  - **Medium 3$/mmbtu**
  - **High 5$/mmbtu**
- **Revenues from CO_2 permits**
  - **None**
  - **20$/tonnes CO_2 captured**
- **Revenues from enhanced hydrocarbon recovery**
  - **Oil (EOR)**
  - **Coal bed methane (ECBM)**

EOR assumptions

- **Max recovery rate 3.5 bbl/tonne CO2 injected**
- **1Mt/year stored**
- **Lasts for 10 years**
- **CO2 recycled (80% of injected CO2 is recycled by year 10)**
- **Upfront development costs approx $180m**

The model

- **Based on Levelized cost of electricity model, adapted version of MIT LCOE model by Du and Parsons, May 2009**
- **The model allows for different forms of blended financing structures**
  - **LCOE methodology finds the price of electricity that covers all generation cost in present value terms (i.e. NPV of the project is equal to zero).**
  - **Model uses weighted Average Cost of Capital (WACC) as discount rate**

Financing structures

Loans	Terms	Case 1	Case 2	Case 3
MDB loan 1	Maturity: 30 years Grace period: 5 years IRR: 4.85%	50%	29%	25%
MDB loan 2	Maturity: 15 years Grace period: 3 years IRR: 4.19%			25%
Commercial loan	Maturity: 15 years Grace period: 4 years IRR: 7.93%	50%		25%
Commercial loan with guarantee	Maturity: 15 years Grace period: 4 years IRR: 6.03%		71%	25%

Similar to IBRD

Similar to EBRD

spread of 400 bps over LIBOR

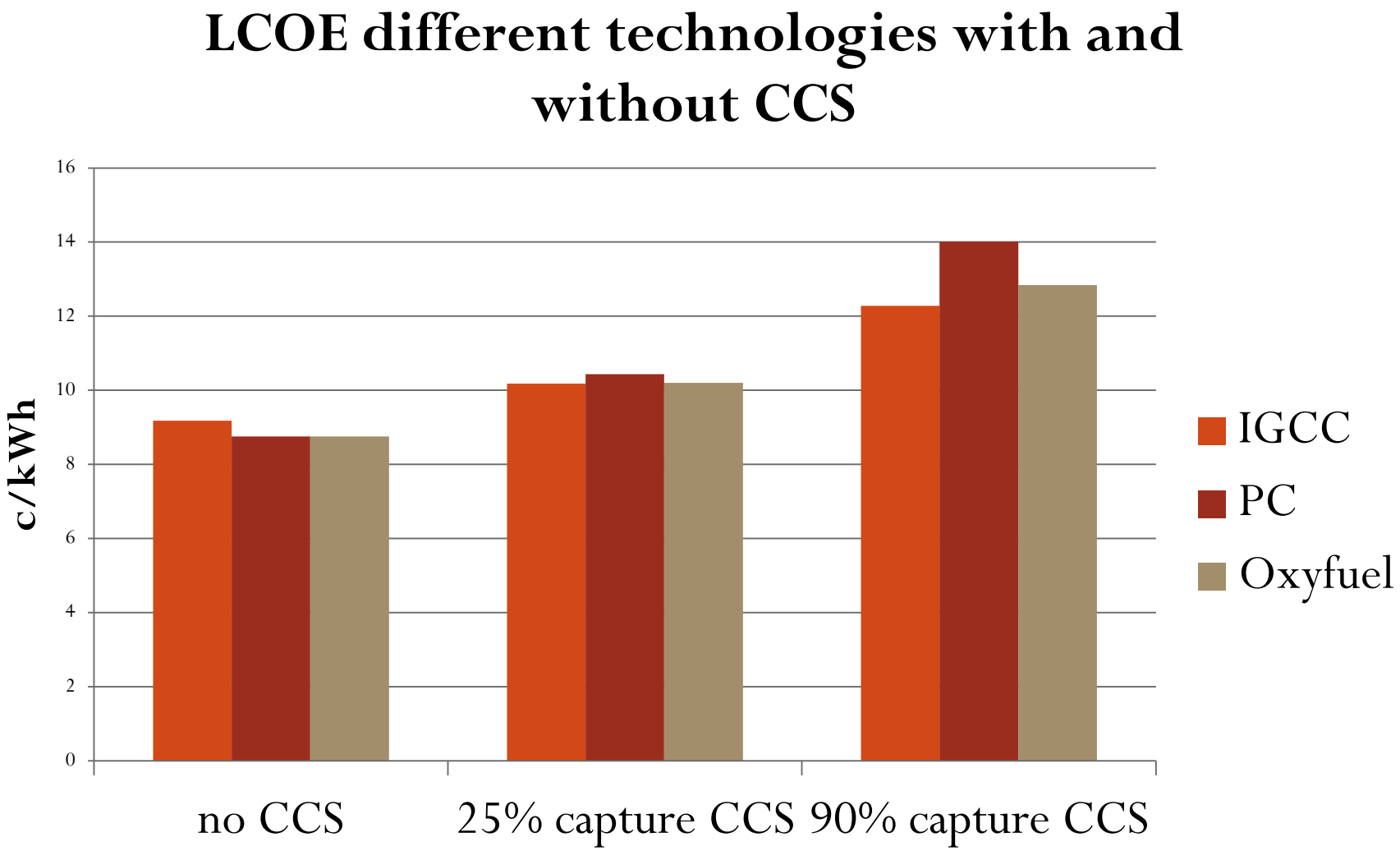
50% cheaper than 1st commercial loan

09/019/2011

Combined Debt rate for 3 cases determines the WACC

Results

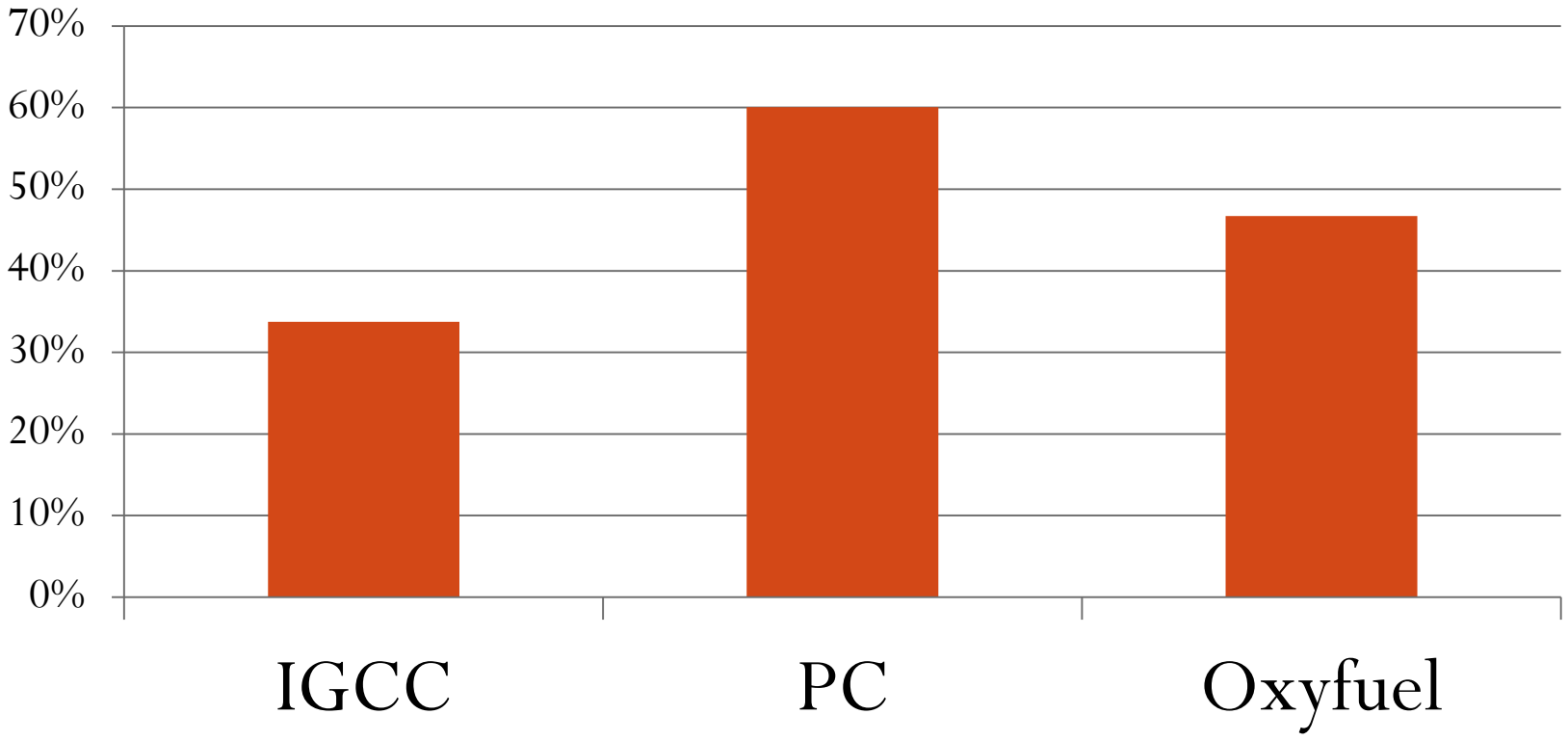
Medium coal price
Case 1: 50/50 MDB1 and commercial loans



Results

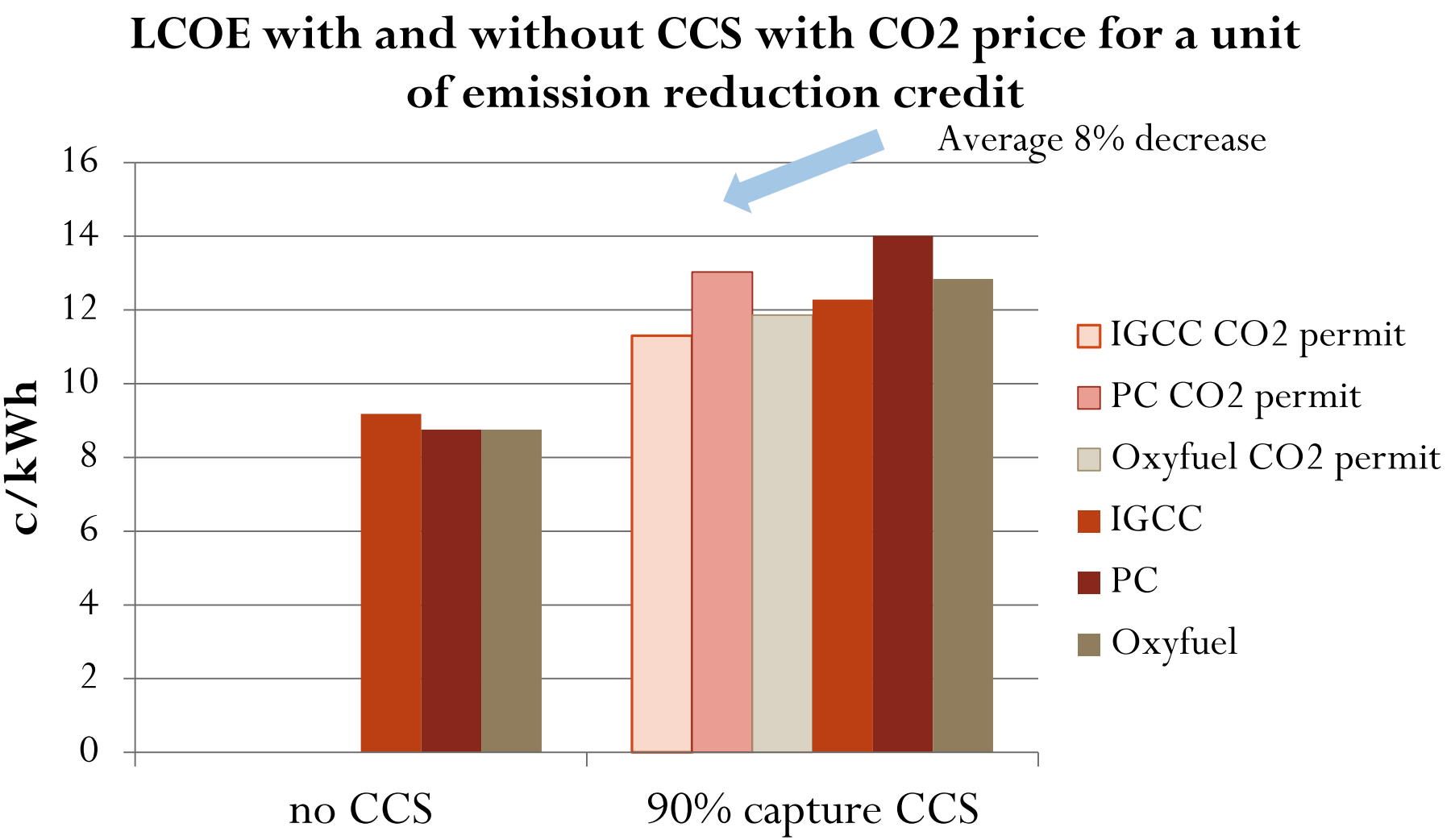
Medium coal price
Case 1: 50/50 MDB1 and commercial loans

Percentage increase in LCOE, no CCS to 90% capture CCS



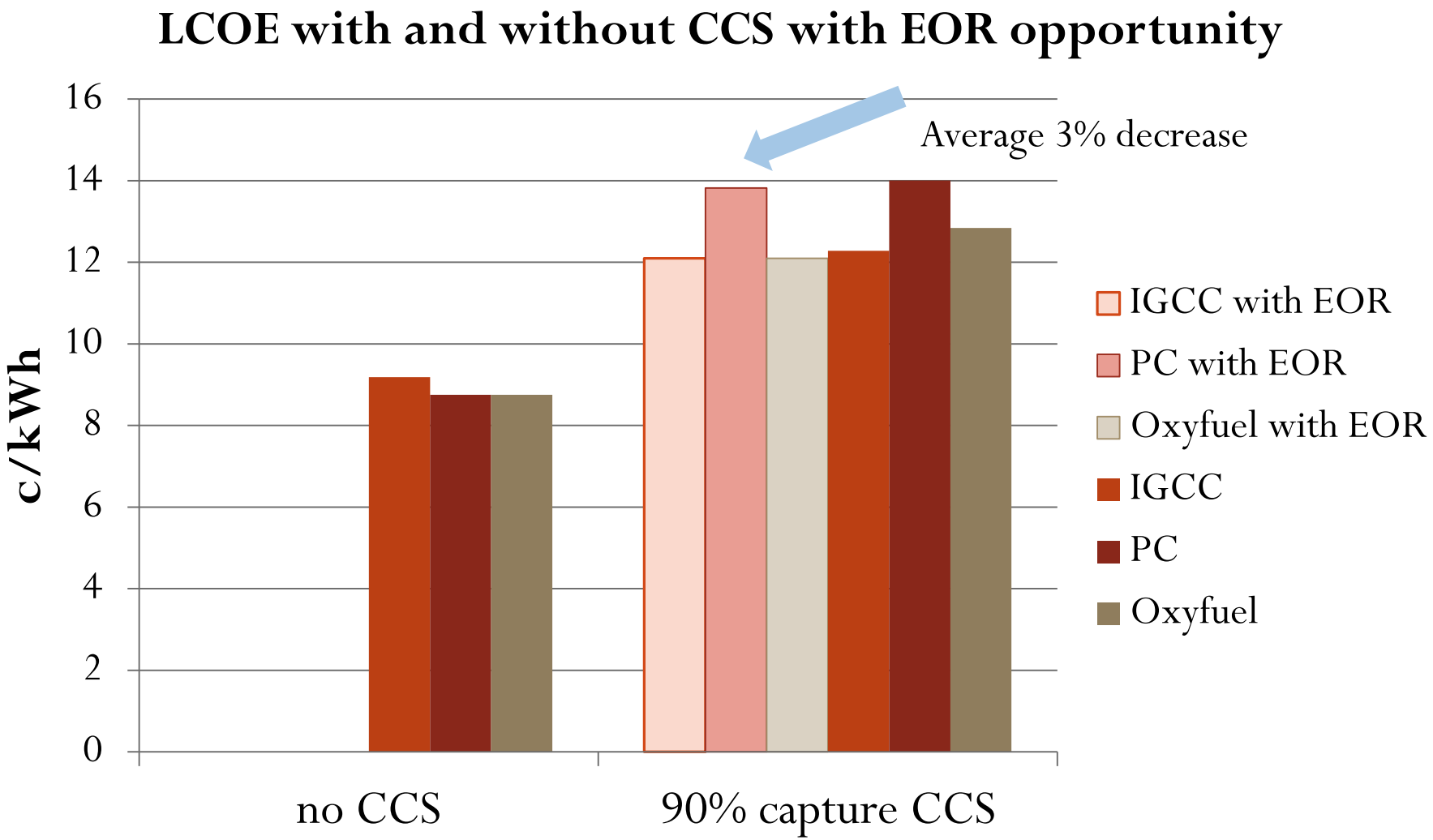
Results

Medium coal price
Case 1: 50/50 MDB1 and commercial loans



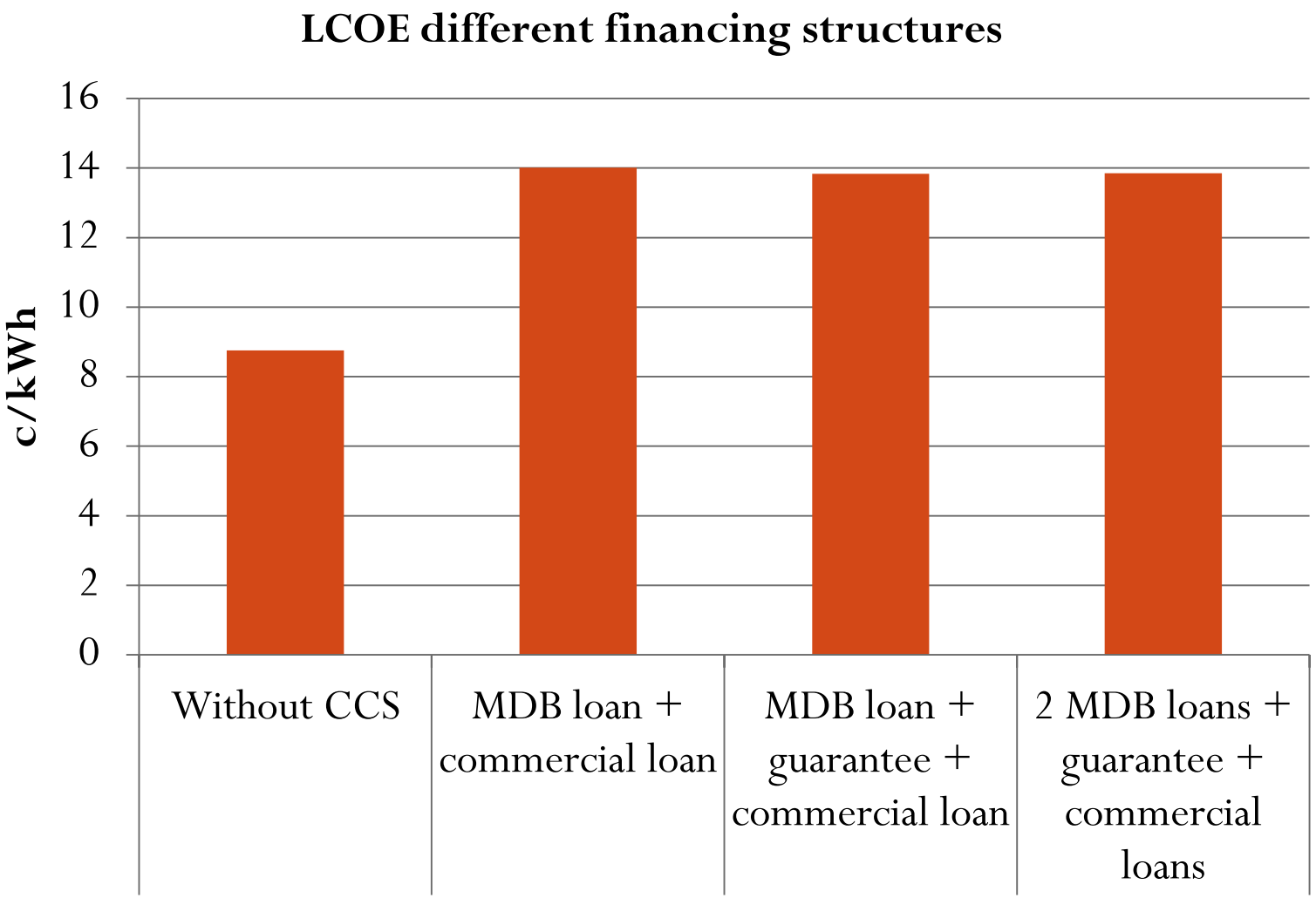
Results

Medium coal price
Case 1: 50/50 MDB1 and commercial loans



Results

Medium coal price
Pulverized coal
No extra revenues



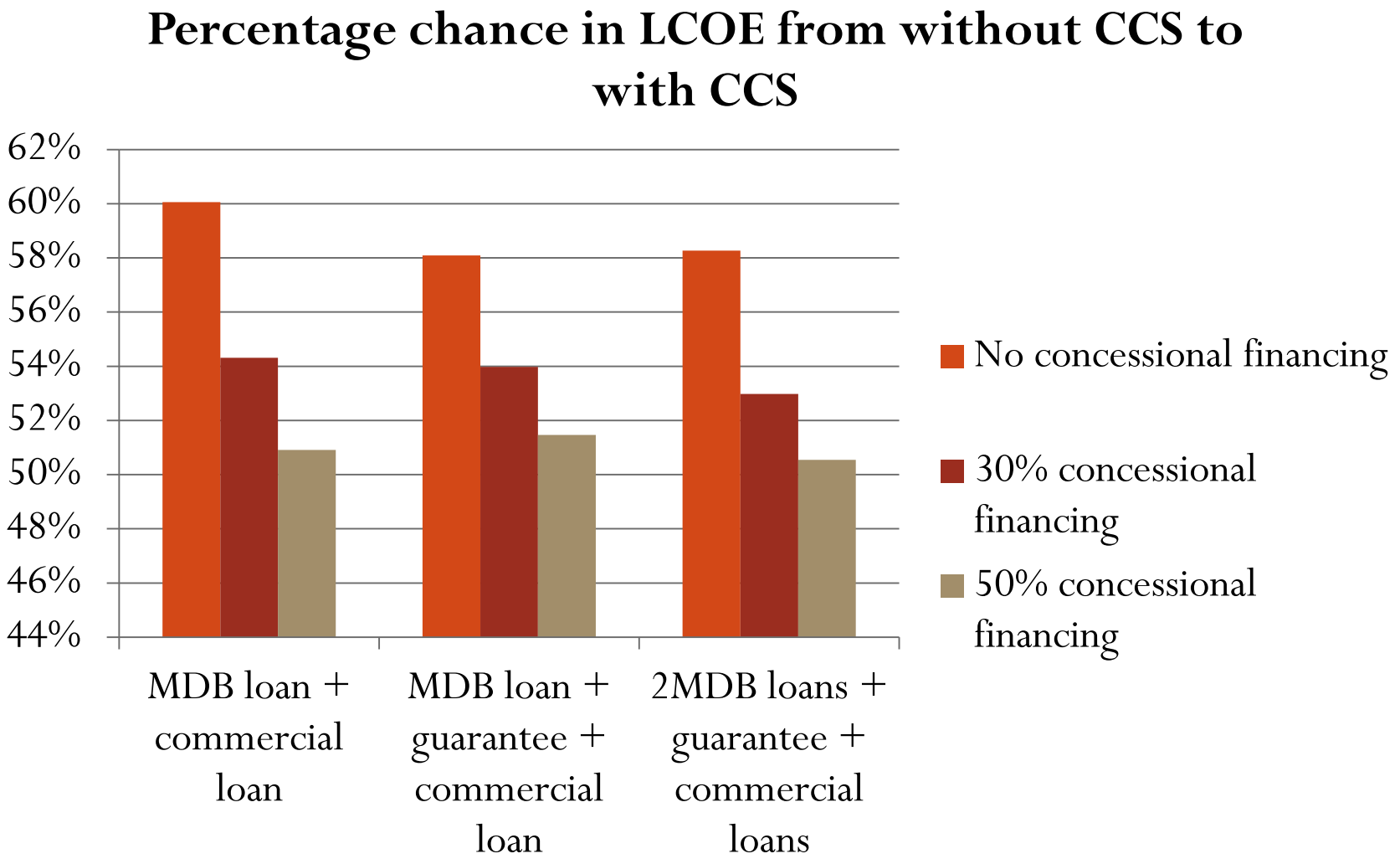
Results

Medium coal price
Pulverized coal
No extra revenues

- **Original method was to find the level of concessional financing that will lower LCOE with CCS to LCOE without CCS.**
- **But, even with 100% concessional financing LCOE with CCS is still higher!**
- **Therefore applied 30% and 50% concessional financing, to see how LCOE changes**
- **Concessional financing terms similar to Clean Technology Fund terms**
  - **Maturity: 20 years**
  - **Grace period: 10 years**
  - **IRR: 0.75%**

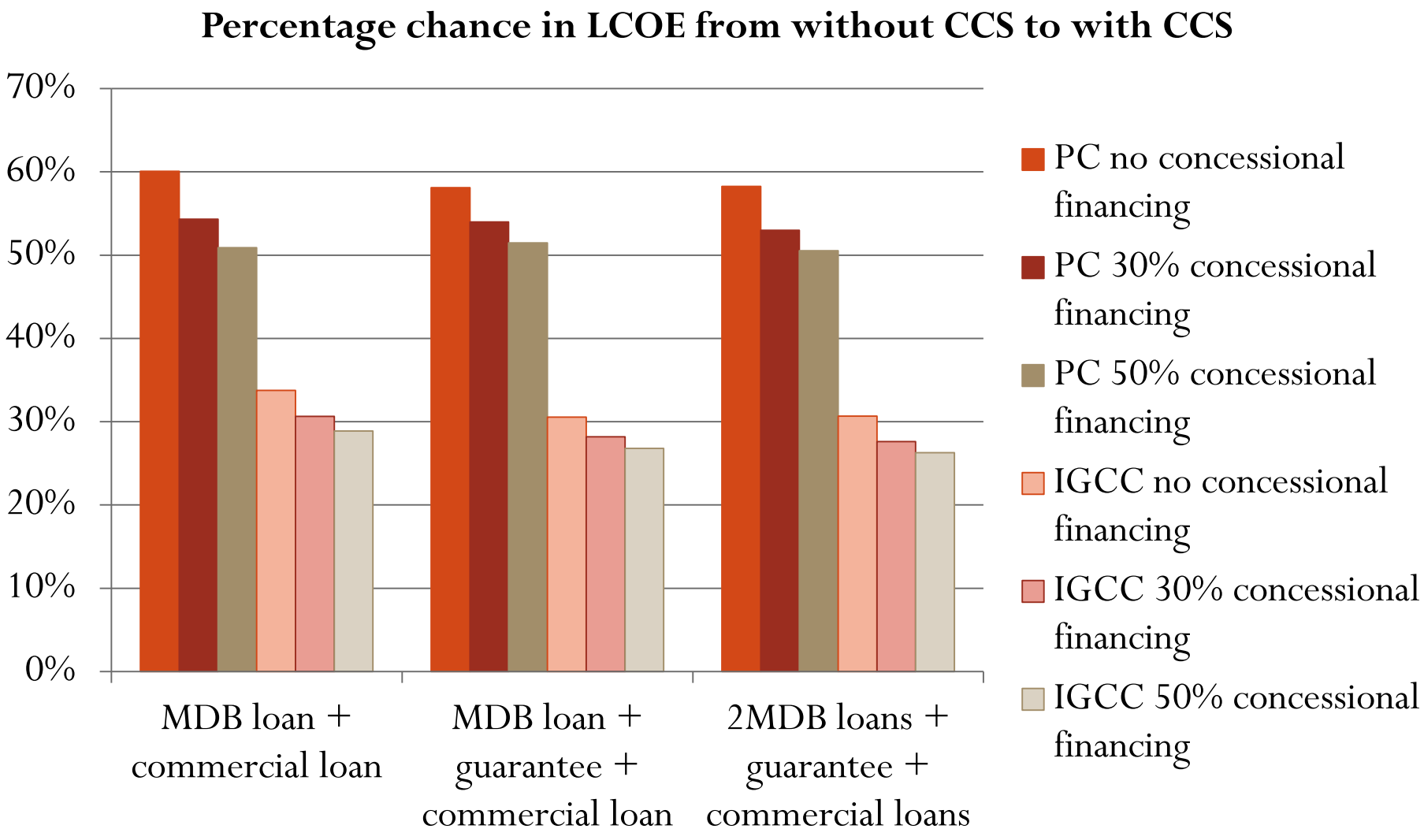
Results

Medium coal price
Pulverized coal
No extra revenues



Results

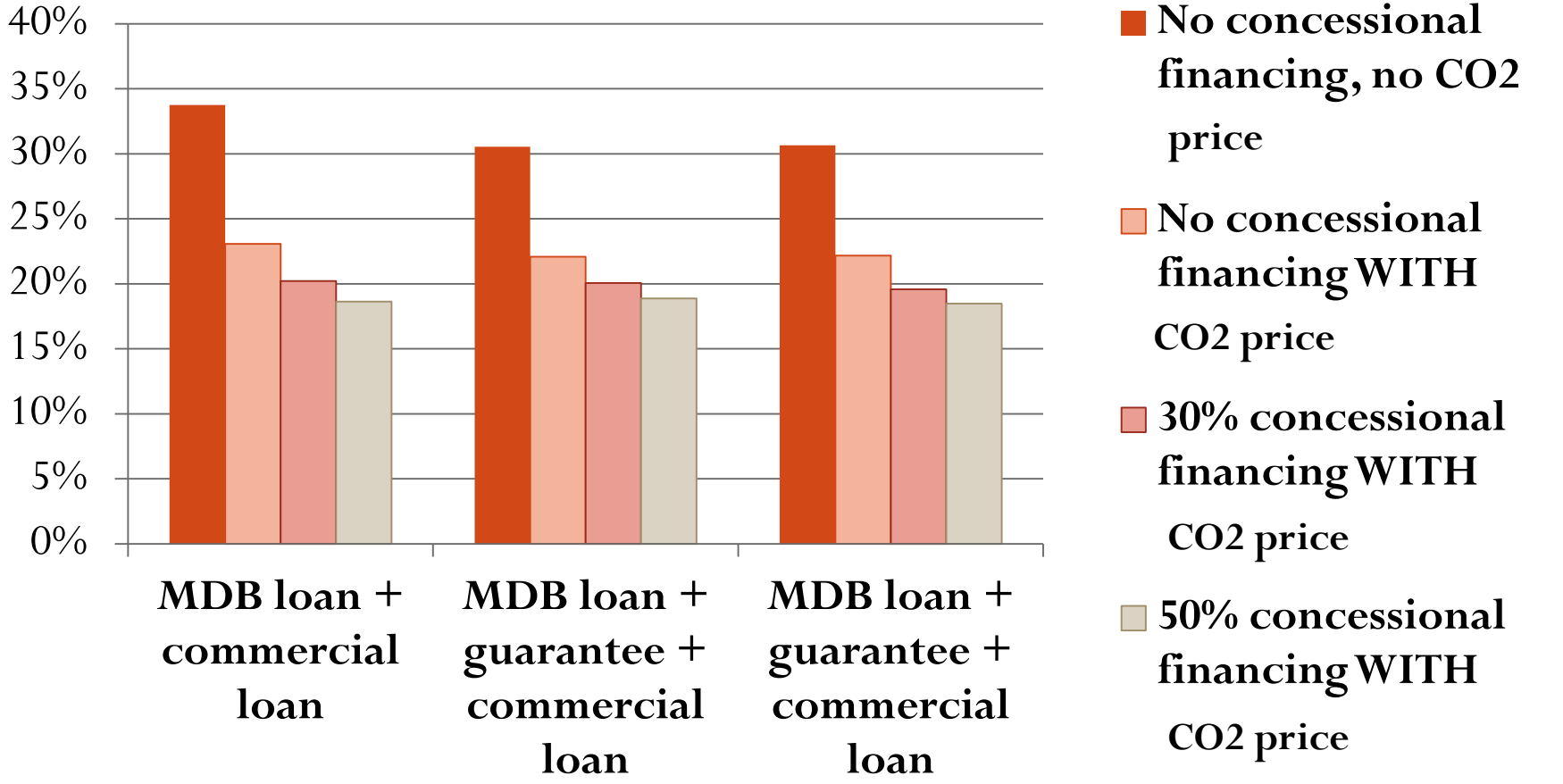
Medium coal price
No extra revenues



Results

Medium coal price
No extra revenues

Percentage change in LCOE from no CCS, with CO2 price



Results

- **Some cases found when concessional finance added, LCOE of plant with CCS was LOWER than LCOE of plant without CCS**
- **% of concessional finance required to set LCOE equal to LCOE of plant without CCS found**
- **Calculated the monetary value of concessional finance**
- **Minimum required concessional finance – oxyfuel with EOR and $50/ton CO2 - $53 million**
- **Maximum required concessional finance – PC with EOR and $50/ton CO2.**

Thank you

The model can be found at:

http://go.worldbank.org/MJIX0TRAB0

Natalia Kulichenko

nkulichenko@worldbank.org