Emerging CO_2 capture technologies and their cost reduction potential

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NETL CO_2 Capture Technology Meeting
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Outline

Study overview

Study scope

Background

- Technology readiness level (TRL)
- Levelised cost of electricity
- Cost learning curves

Findings

- Drivers of capture cost
- Energy consumption
- Contributions to cost of electricity
- TRL comparisons

Summary

Conclusions

Study overview

Study commissioned by UK DECC

Study carried out by Mike Haines (former IEAGHG staff), with input from IEAGHG capture team (PM John Davison)

Interim report published as an IEAGHG Technical Review (2014/TR4)

- Not subject to external peer review
- Draft executive summary is included

Aim to publish as a "full IEAGHG report"

- External reviews have been obtained and revisions are being made
- Revised executive summary will be reviewed by IEAGHG ExCo members before publication

Study scope (1)

Determine cost drivers (fuel/capital/other costs) for power generation technologies with CO_2 capture

Review theoretical energy consumptions for CO_2 capture and compare to actual consumptions

Review cost progression for new technologies

Study scope (2)

Identify and review the main emerging capture technologies being developed for power plants

- Post-combustion capture
- Pre-combustion capture
- Oxy-combustion
- Solid looping

Assess current status and Technology Readiness Level (TRL)

Critically assess claims for energy requirements and cost reductions

Capture in non-power industries considered in less detail

Study did not involve detailed assessment of energy requirements and costs of plants with CO_2 capture

Technology readiness level

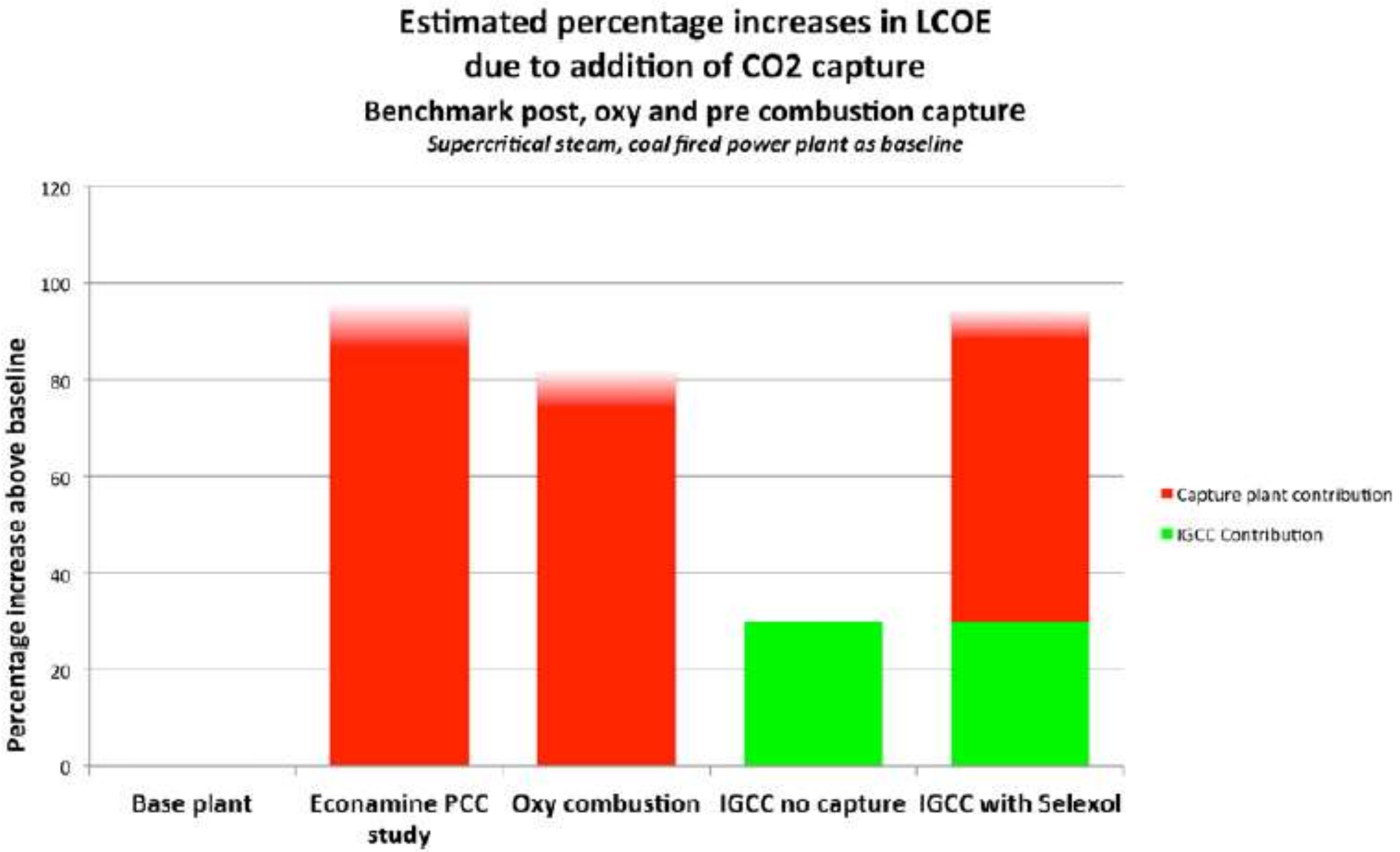
	9	Normal commercial service
Demonstration	8	Commercial demonstration, full scale deployment in final form
	7	Sub-scale demonstration, fully functional prototype
	6	Fully integrated pilot tested in a relevant environment
Development	5	Sub-system validation in a relevant environment
	4	System validation in a laboratory environment
	3	Proof-of-concept test, component level
Research	2	Formulation of the application
	1	Basic principles, observed initial concept

Source: EPRI

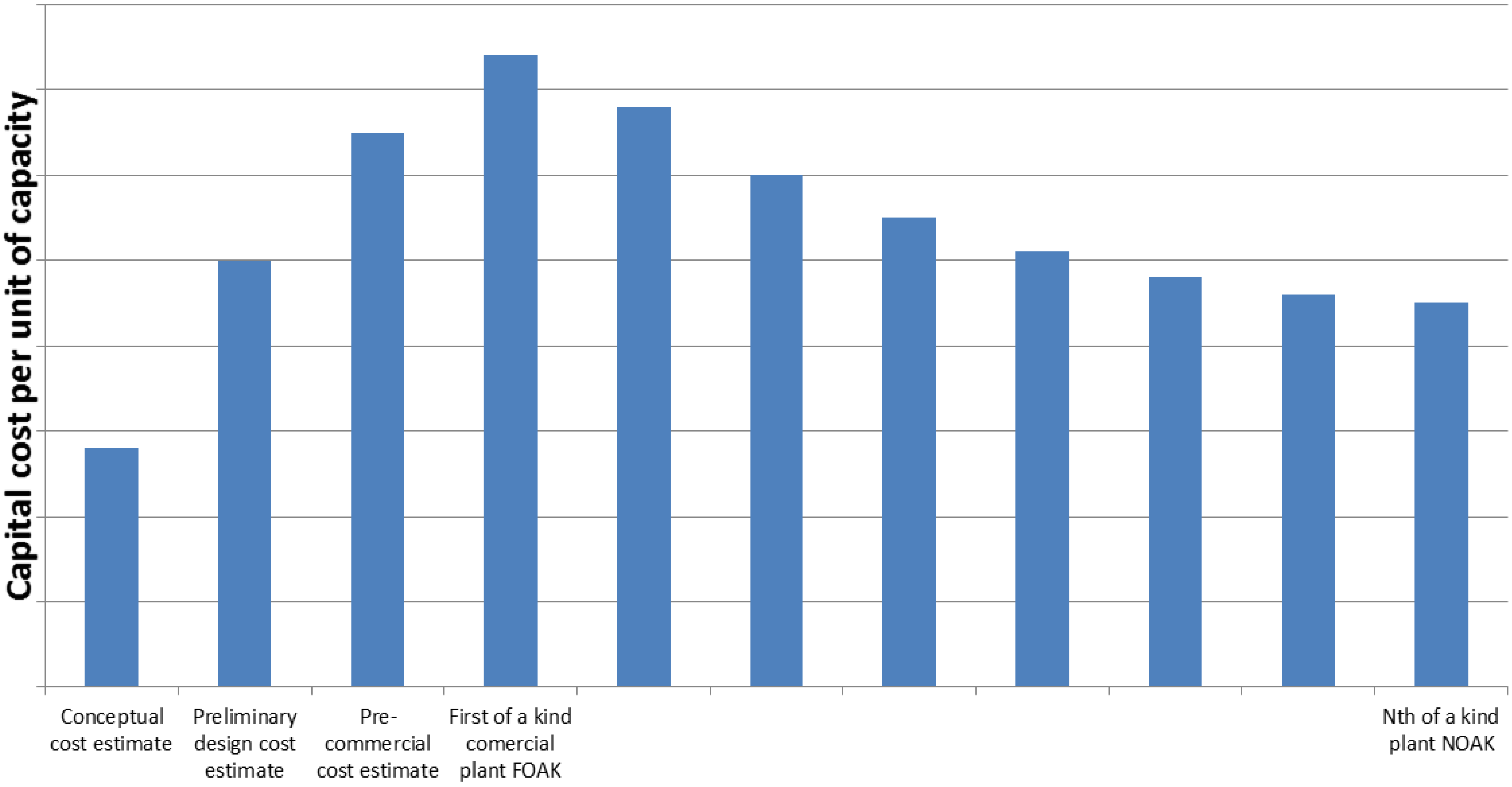
Note:

- *TRL is not necessarily an indication of the amount of time and effort required to achieve commercialisation*
- *TRL 9 does not necessarily represent the be-all and end-all*

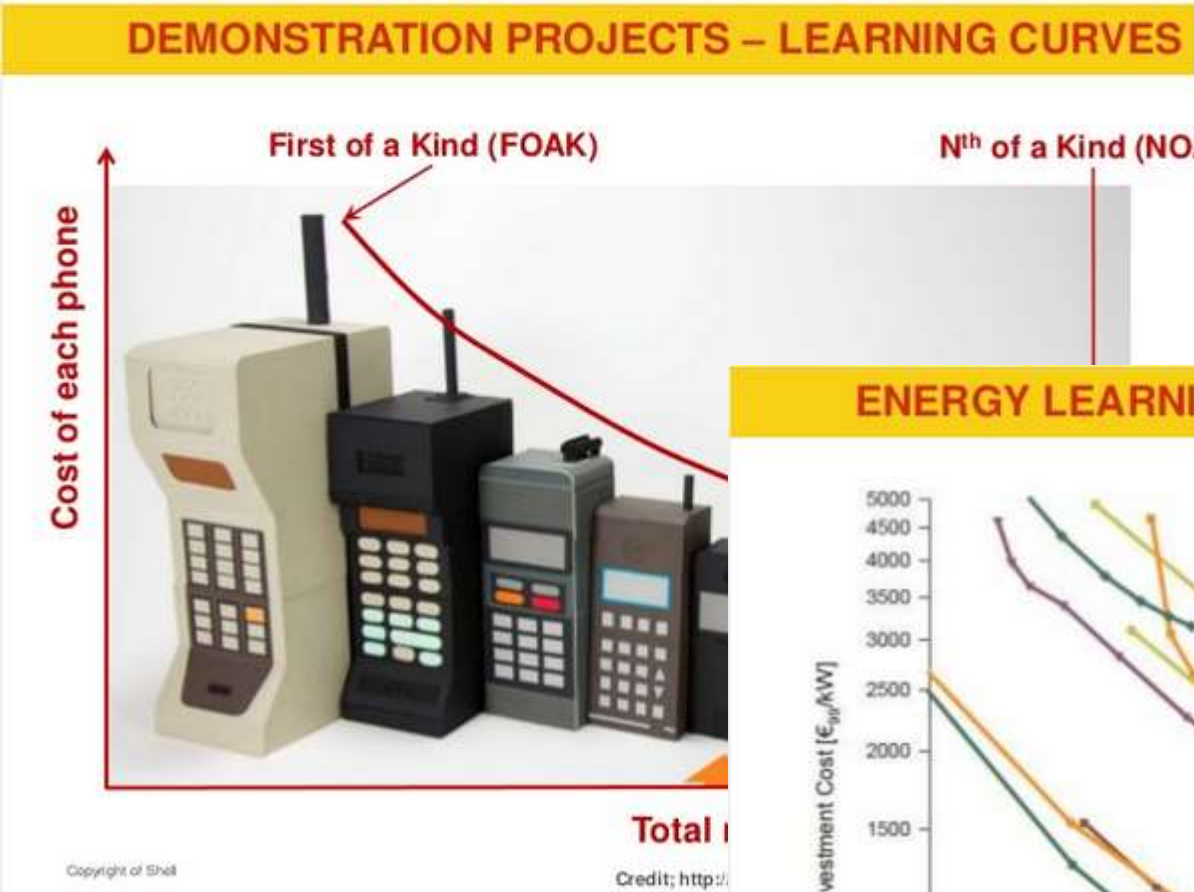
Estimated LCOE increase

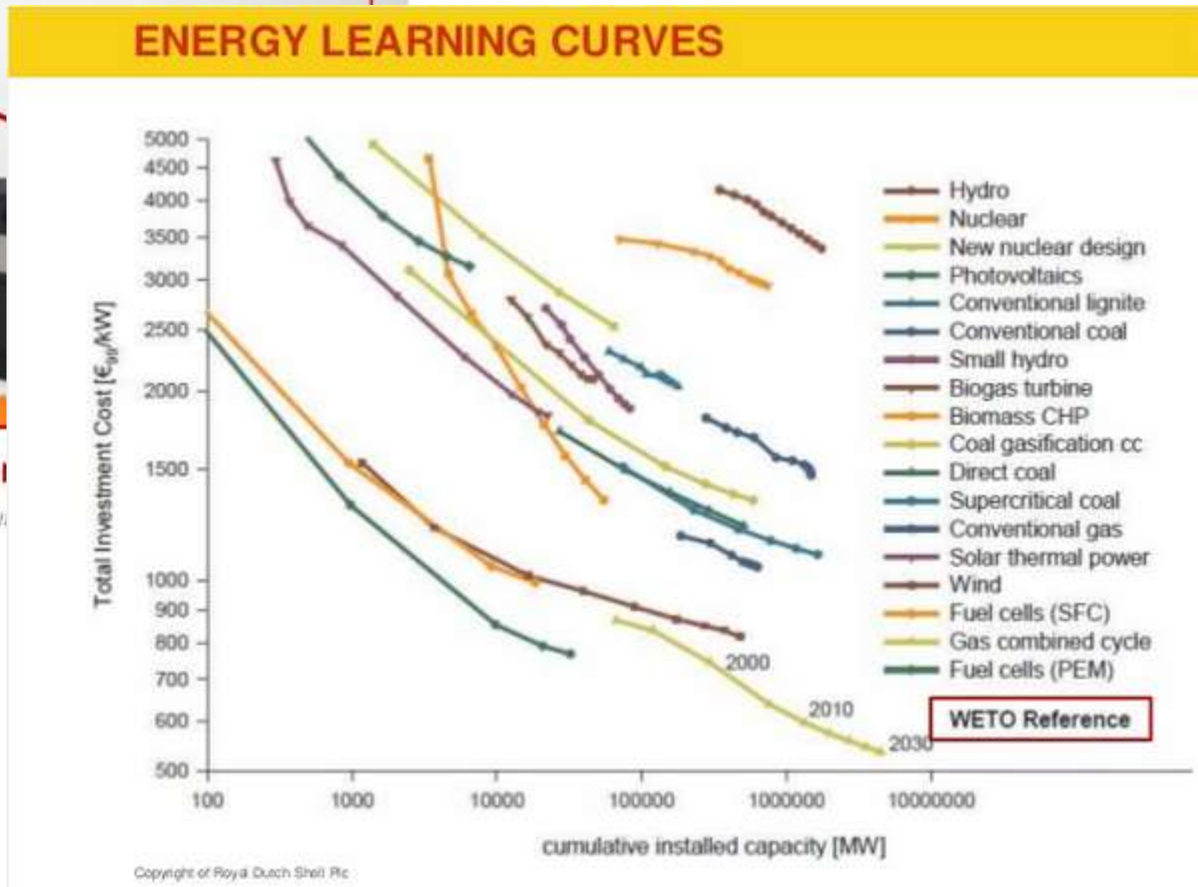


Cost learning curve



Other cost learning curves





Drivers for cost of capture

Capital cost of capture equipment

- Capital charges, cost of maintenance etc.

Increased fuel consumption

Increased specific capital cost of the host power generation process due to increased fuel consumption

Increased variable operating costs

- Capture solvent make-up etc.

→Early stage assessments tend to focus initially on energy consumption

- Can be evaluated more scientifically
- A major contribution to capture cost

Energy consumption

CO_2 separation

- Theoretical work for post-combustion capture from coal fired power plant flue gas: 0.15 GJ/t CO_2
  - Equivalent to <1.5% points of power plant efficiency
- Scope to reduce energy consumption but all processes need a significant driving force to reduce equipment size
- Some capture processes use exergy that is otherwise wasted

CO_2 compression

Miscellaneous power

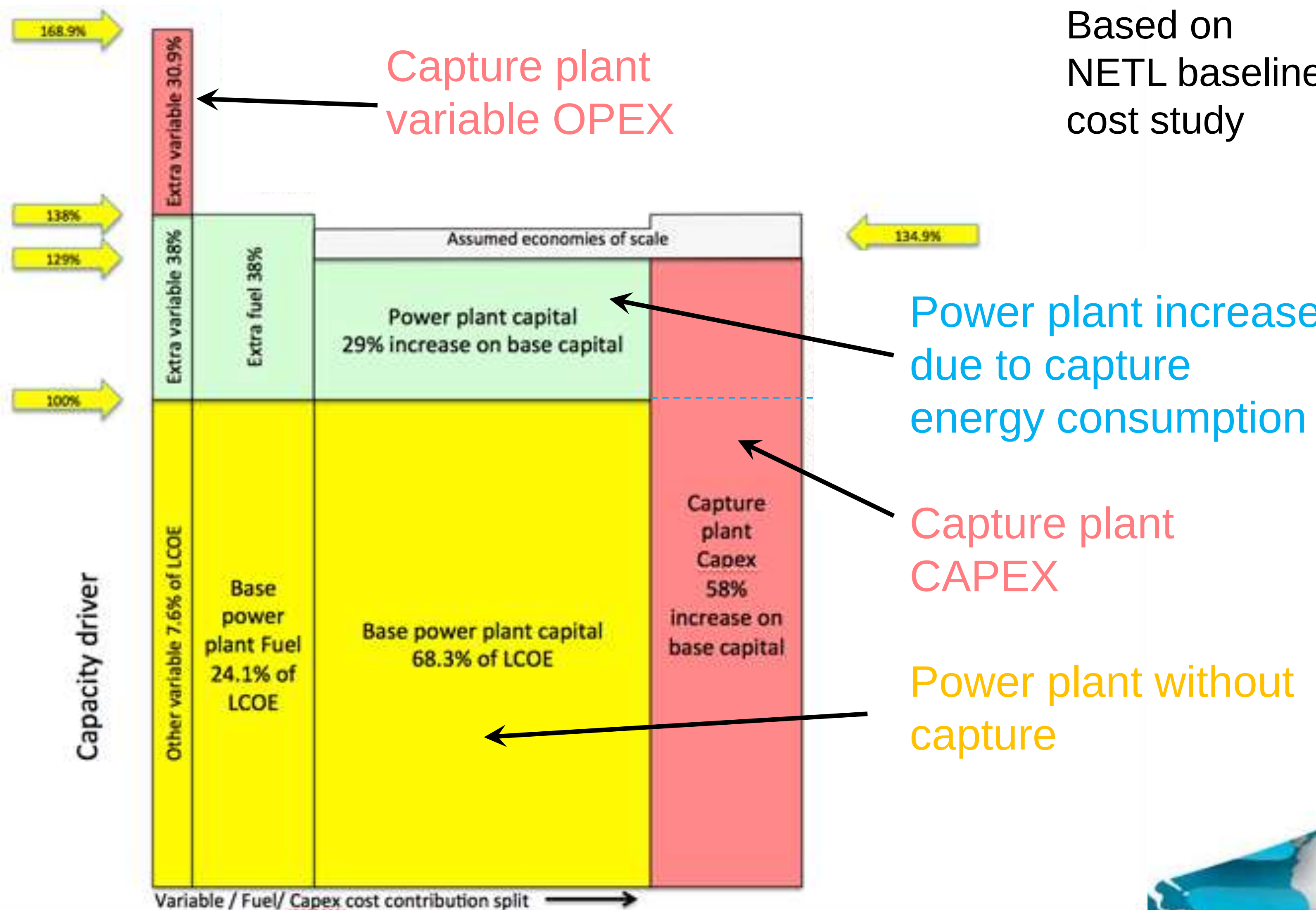
Other losses

- E.g. shift conversion for pre-combustion capture

Post-combustion capture

Contributions to cost of electricity

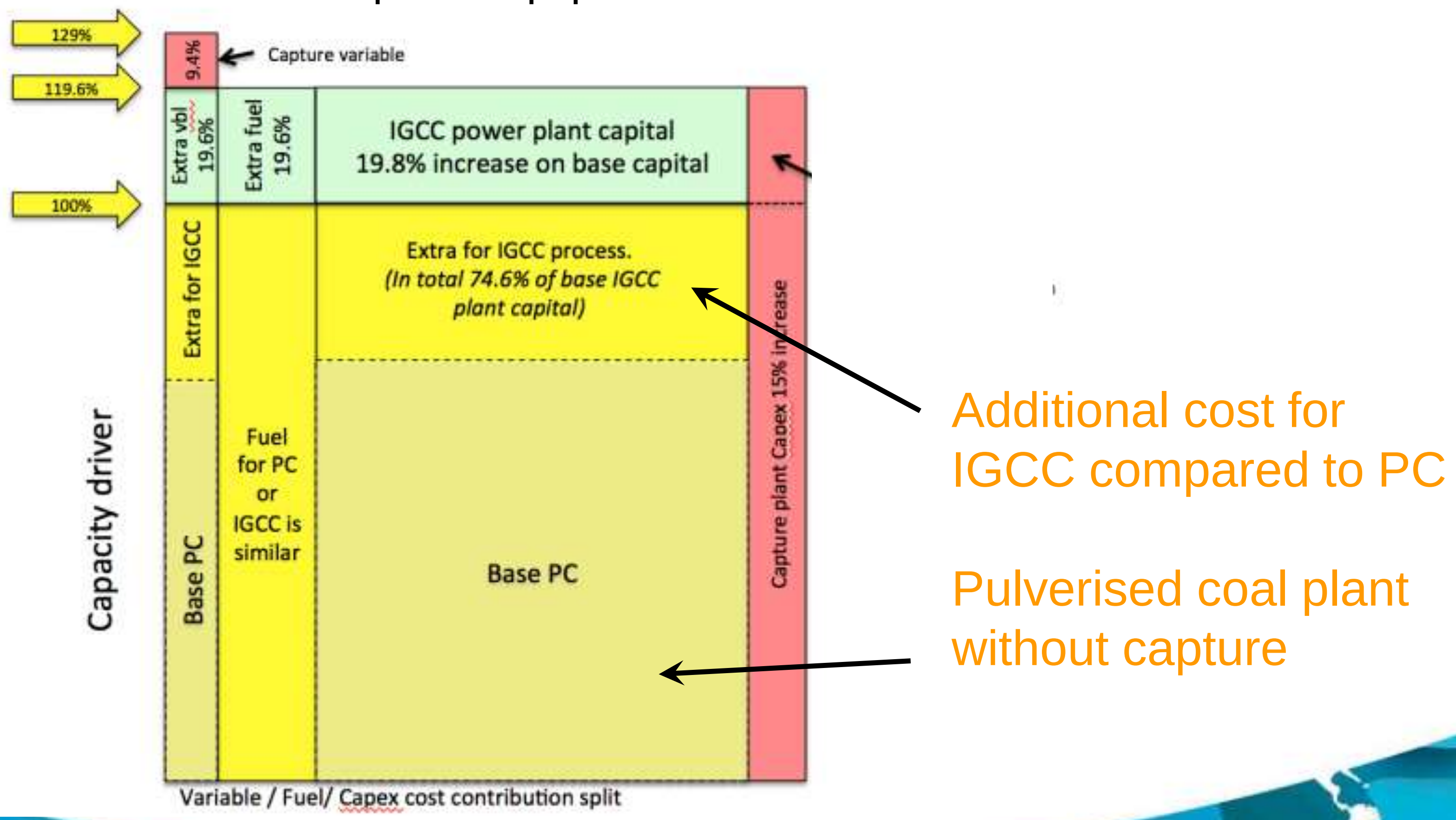
Based on NETL baseline cost study



Pre-combustion capture

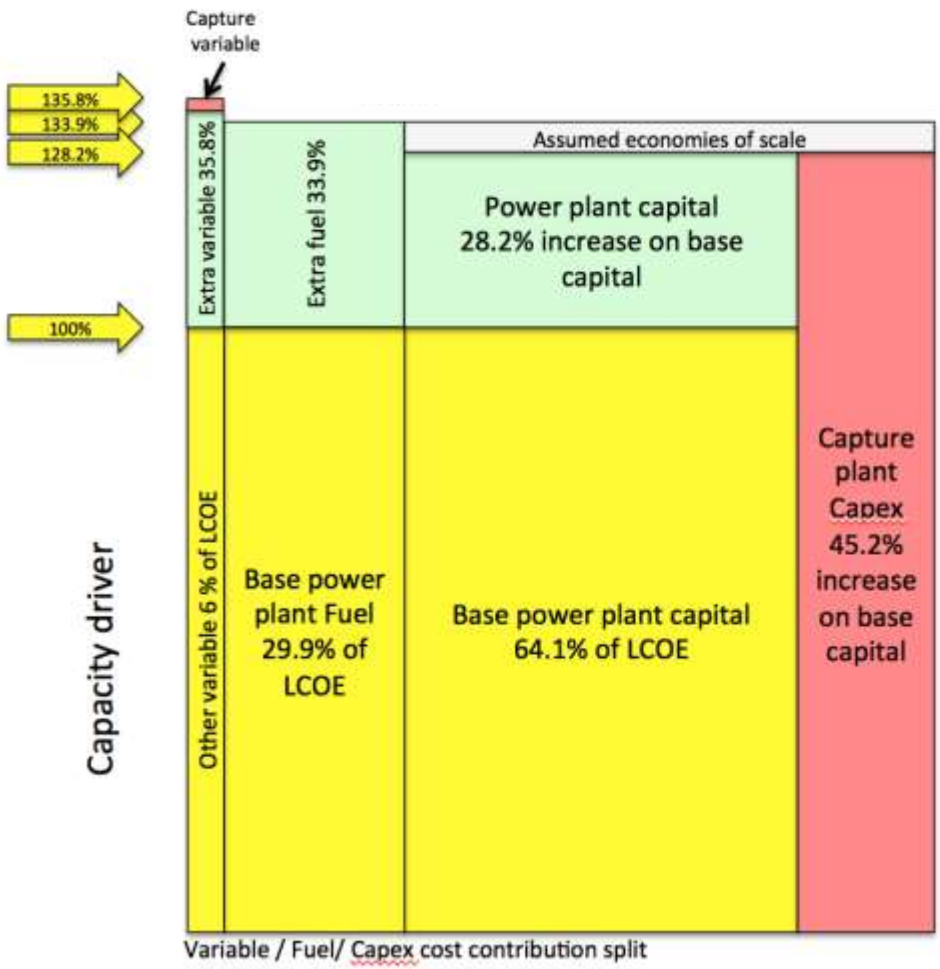
Contributions to cost of electricity

- Baseline integrated gasification combined cycle (IGCC) without capture is more expensive than baseline pulverised coal (PC) plant without capture – need to reduce core IGCC costs
- Extra cost of capture equipment is lower than for PC



Oxy-combustion capture
Contributions to cost of electricity

- Broadly similar to PC with post-combustion capture



Post-combustion capture

TRL 7 – 9

- Benchmark amine scrubbing
- Improved conventional solvents

TRL 4 – 6

- Bi-phasic solvents
- Precipitating solvents
- Polymeric membranes
- Temperature swing adsorption

TRL 1 - 3

- Enzyme catalysed adsorption
- Ionic liquids
- Room temperature ionic liquid (RTIL) membranes
- Encapsulated solvents
- Electrochemically mediated absorption
- Vacuum pressure swing adsorption (VPSA)
- Cryogenic capture
- Supersonic inertial capture

Pre-combustion capture

TRL 7 – 9

- IGCC with Selexol

TRL 4 – 6

- Hydrogen separation membranes
- Sorption enhanced water gas shift (SEWGS)
- Integrated gasification fuel cells (IGFC)

TRL 1 - 3

- Low temperature separation

Oxy-combustion capture

TRL 1 - 3

- Oxy-combustion gas turbines: other cycles

TRL 4 – 6

- O_2 production: ion transport membrane (ITM), O_2 transport membrane (OTM), ceramic auto-thermal reforming systems (CARS)
- Oxy-combustion gas turbines: water cycle

TRL 7 – 9

- Benchmark coal oxy-combustion

Solid looping processes

TRL 1 - 3

- Sorption enhanced reforming (SER)
- Chemical looping gasification (CLG)
- Chemical looping with oxygen uncoupling (CLOU)
- etc.

TRL 4 – 6

- Calcium carbonate looping (CaL)
- Chemical looping combustion (CLC)

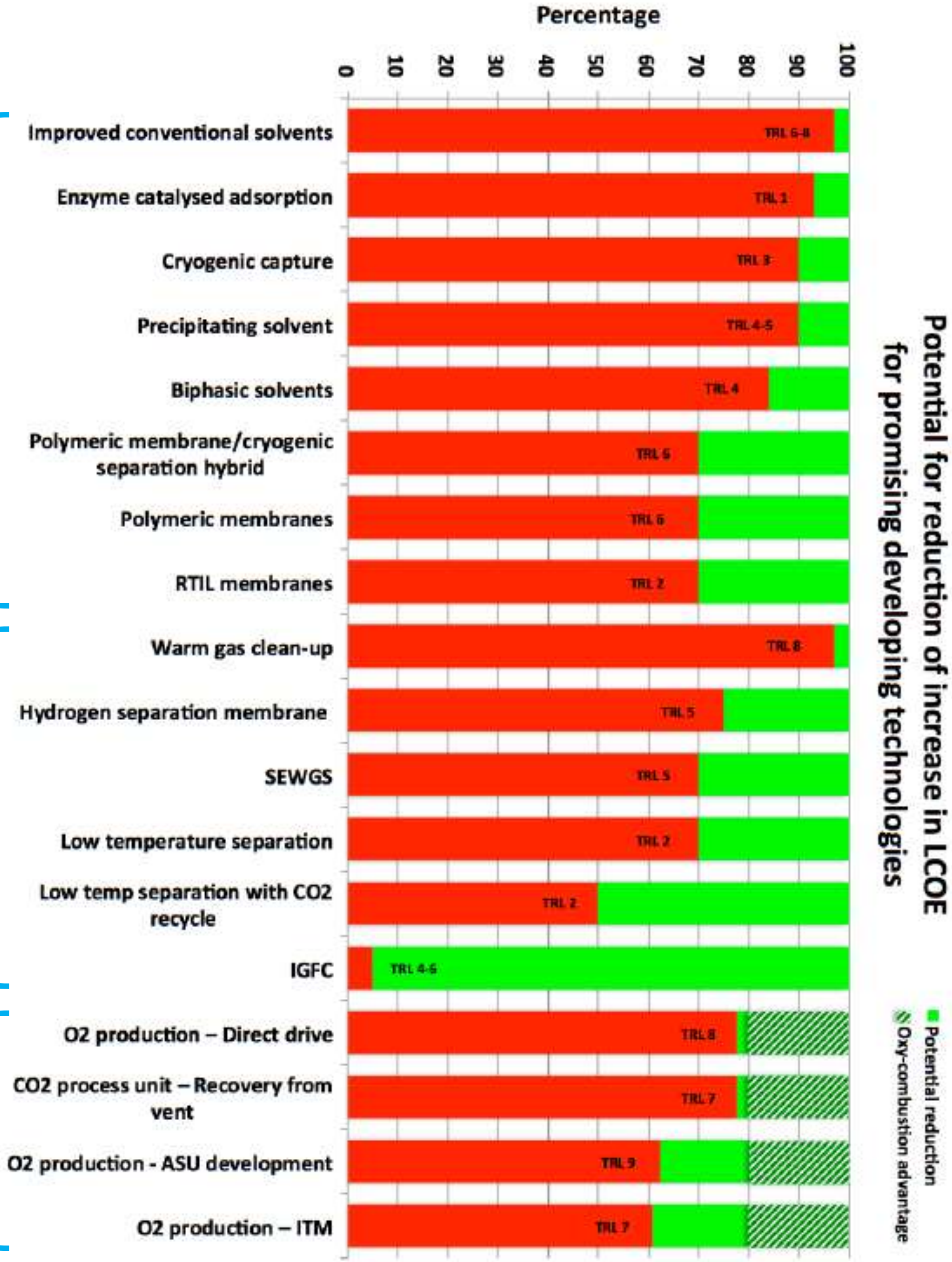
TRL 7 - 9

Summary

Post-combustion capture

Pre-combustion capture

Oxy-combustion capture



Conclusions

Many new technologies for CO_2 capture are being developed

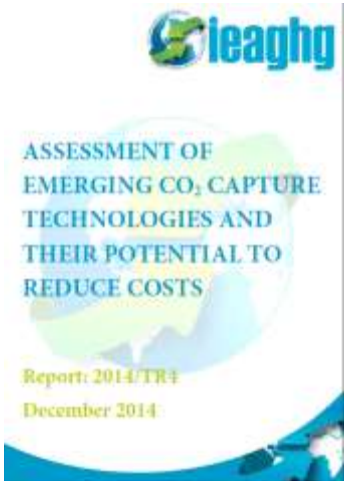
Estimated costs of new capture technologies are subject to high uncertainty, especially at low TRLs

Processes in which CO_2 capture is a more integrated part of the power generation process show high potential for energy and cost reduction but have significant development hurdles

- E.g. solid looping combustion, oxy-combustion turbines and fuel cells

Thank you, any questions?

PCCC3
Post Combustion Capture Conference
8th - 11th September 2015, Regina, Canada



http://www.ieaghg.org/publications/technical-reports

6th HTSLCN Meeting,
1st – 2nd September, Milan, Italy

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