CO₂ Capture Project

Cost Estimation and Selection of Technologies

Torgeir Melien, Norsk Hydro

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This presentation

- Approach

- Challenges

- Status

- Remaining work

Approach

- **Capture technologies**
  cost-reducing development of pre/oxy/post- technology options within the context of ..

- **"Scenarios"**
  or representative, real-life industrial plant applications

- **"Baseline"**
  capture technologies (mainly post-comb/ amine-solutions) established as benchmarks in evaluating ...

- **New or Advanced Technologies'**
  capture performance and cost reduction potentials
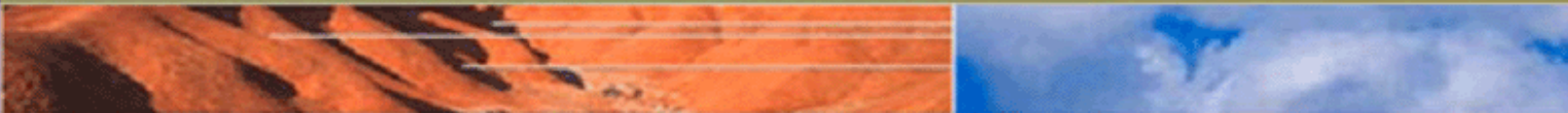
CCP Scenarios

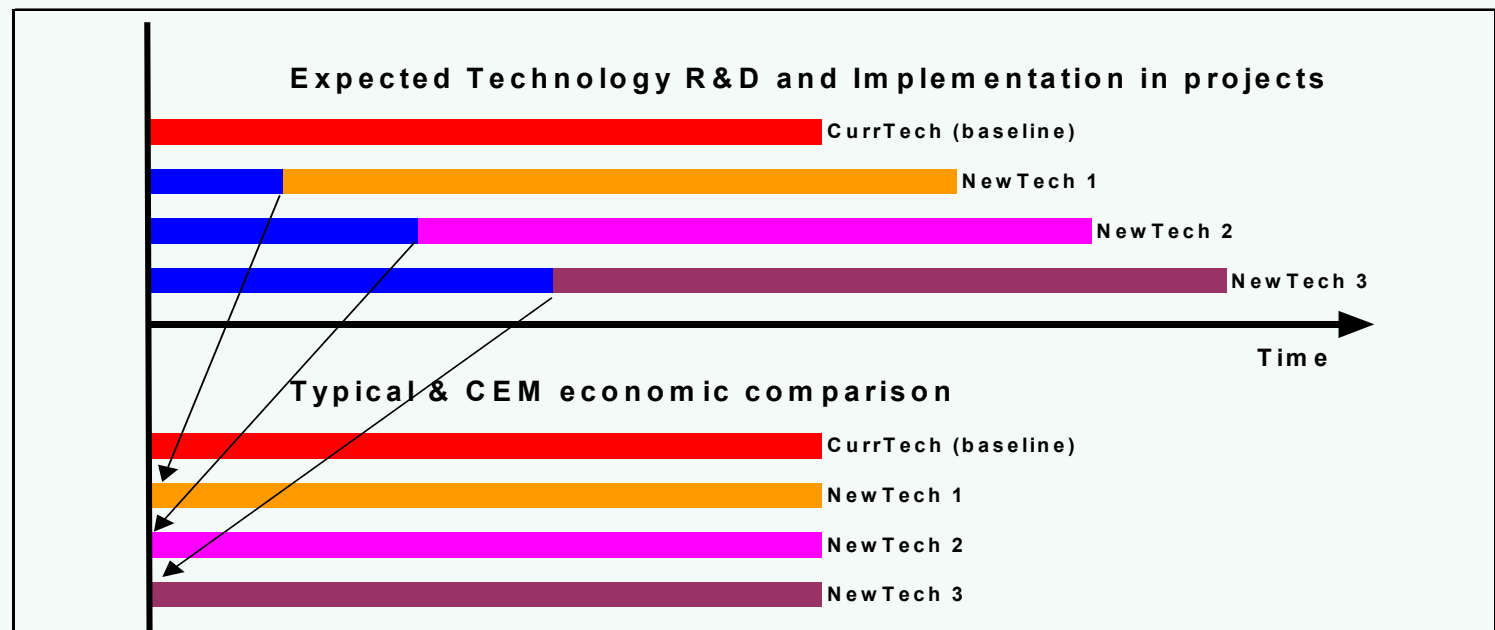| Scenario	Fuel Source	CO₂ Source	Geologic Sink	Location
Refinery (existing)	Refinery Fuel Gas & Liquids	Heaters & Boilers	Storage	**UK** Refinery
Large Gas Turbines (new/ non-built)	Natural Gas	Large Electric Power Generation (CCGT)	Storage	Western **Norway**
Distributed Gas Turbines (existing)	Natural Gas	Small Distributed turbines	Storage	**Alaska** North Slope
Gasification (new/ non-built)	Solid gasification (petroleum coke)	Steam, H_2, & Electricity Cogeneration	Storage	Western **Canada**

"Scenario-Technology matrix"

		Alaska		Canada		EU Refinery		Norway	
		New	Retro	New	Retro	New	Retro	New	Retro
Post-Combustion									
	ESA	Hi	Hi	Hi(2)		Hi	Hi	Hi	
	MHI/Kvaerner	Hi	Hi	N/A (3)		Hi	Hi	Hi	
	HydroChannel	Hi	Hi	N/A		Hi	Hi	Hi	
	Radical Chem	Lo/Med (4)	Lo/Med (4)	Lo/Med (4)		Lo/Med (4)	Lo/Med (4)	Lo/Med (4)	
	ABB TSA	Hi	Hi	Med		Hi	Hi	Hi	
	Unit Optimisation	Medium	Medium	Low		Medium	Medium	Medium	
	Reduced Standards (1)	Medium	Medium	Low		Medium	Medium	Medium	
Pre-Combustion									
	Baseline	N/A	N/A	Hi		N/A	N/A	N/A	
	WGS Membrane	Hi	Hi	Hi		Hi	Hi	Medium	
	Membrane Reformer	Hi	Hi	Medium		Hi	Hi	Hi	
	VLS ATR	Hi	Hi	N/A		Hi	N/A	N/A	
	Compact Refomer	Low	Low	Low		Hi	Low	Low	
	Membrane contactor	Hi	Hi	Hi		Hi	Hi	Hi	
	ESA	Hi	Hi	Hi		Hi	Hi	Hi	
	SEWGS	Hi	Hi	Low		Hi	Low	Medium	
	ITM/OTM	Medium	Medium	Hi		Medium	Medium	Medium	
	Advanced Gasification	Medium	Medium	Hi		Medium	Hi	Low	
	IFE	Hi	Hi	Hi		Hi	Hi	Hi	
	Standardised PCDC	Medium	Medium	Low		Low	Low	Hi	
OxyFuel									
	Baseline	N/A	N/A	N/A		N/A	N/A	N/A	
	Boilers/heaters with recycle	N/A	N/A	N/A		Hi	Hi	N/A	
	GT with flue gas recycle (HiOx)	Hi	N/A	N/A		N/A	N/A	Hi	
	Membrane boiler (Praxair)	N/A	N/A	N/A		Hi	Low	N/A	
	Membrane with GT (AZEP)	Hi	Hi	N/A		N/A	N/A	Hi	
	Chemical looping	N/A	N/A	N/A		Hi	Low	N/A	
	Baselines		x	x			x	x	

Comparing mature & non-mature Technologies

- Estimates and screening basically covering <u>realization phase</u> of technologies
  - i.e not incl. pre-realisationTech. Development/ R&D-costs (blue lines)
  - handles Technologies at various development states similarly
- Partly compensated in CEM-/TaskForce work by
  - qualitative/ semi-quantitative scoring on Tech.devt. aspects
  - introducing "current" and "future" states of non-mature technology

Expected Technology R&D and Implementation in projects

- CurrTech (baseline)
- NewTech 1
- NewTech 2
- NewTech 3

Time

Typical & CEM economic comparison

- CurrTech (baseline)
- NewTech 1
- NewTech 2
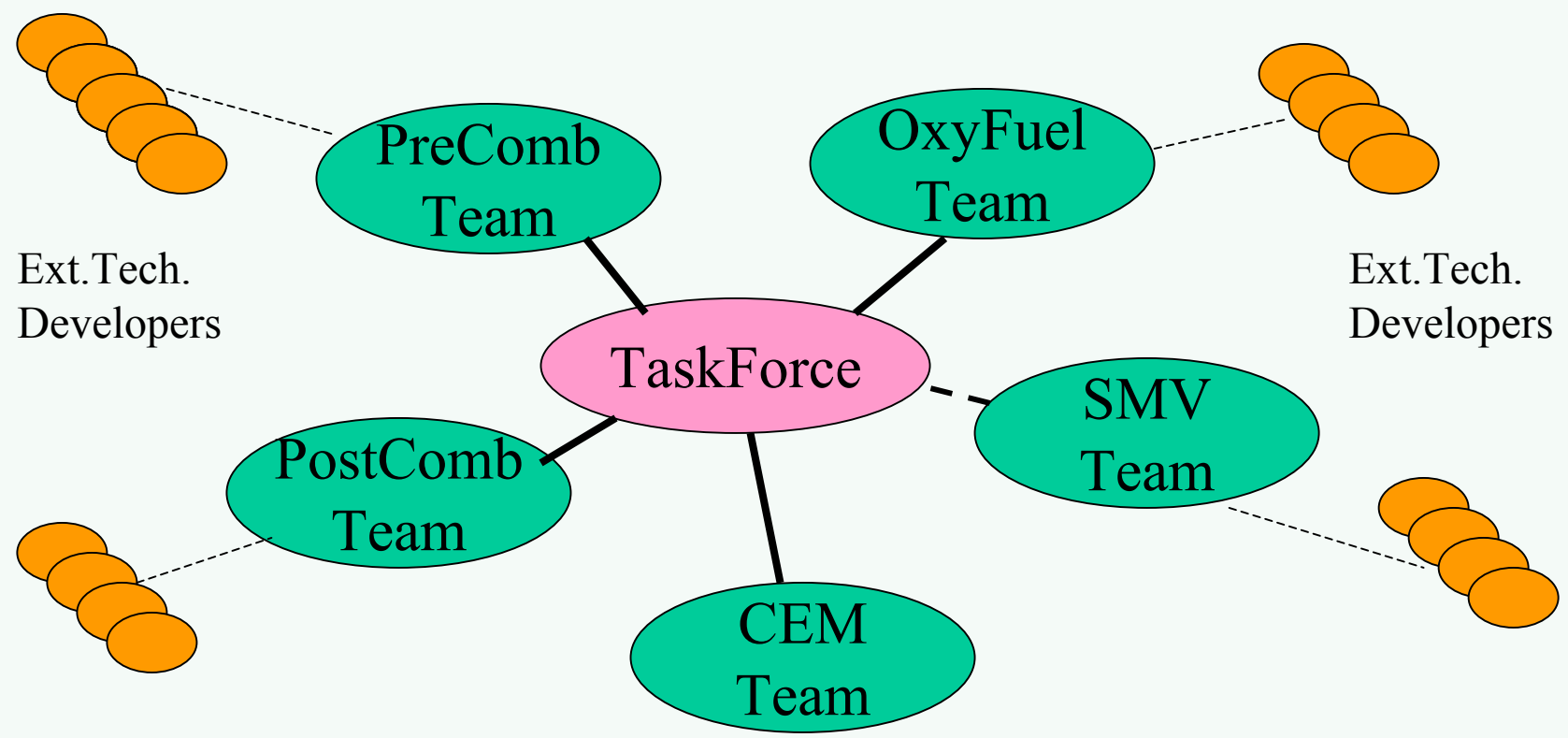- NewTech 3

Consistency in estimation and screening

Transforming a multitude of individual
Technology studies into a comparable
and quantified set of Scen-Tech options

- Integrating capture technologies
  into scenarios

- Calibrating physical scopes
  and capacities

- Capex vs. opex tradeoffs

- Capex & opex estimation
  methods and assumptions

- Consistent CO2-cost evaluation

Individual Tech. Developer Studies

Common
Cost
Estimation

Common
Economic
Screening
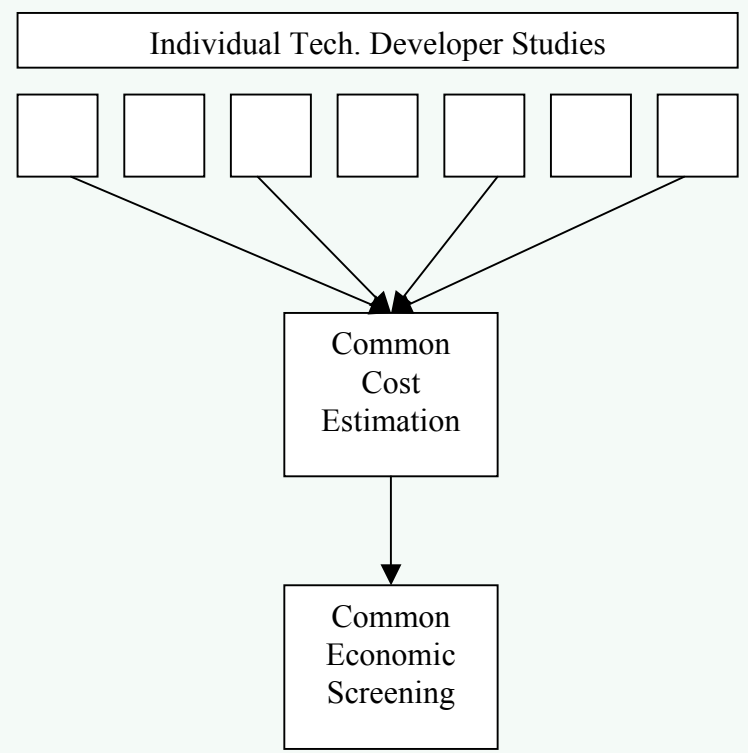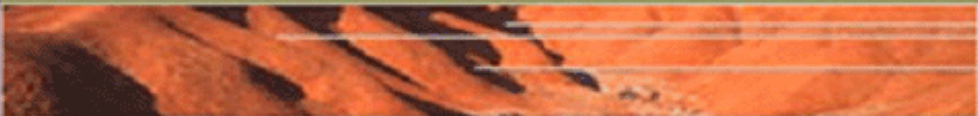
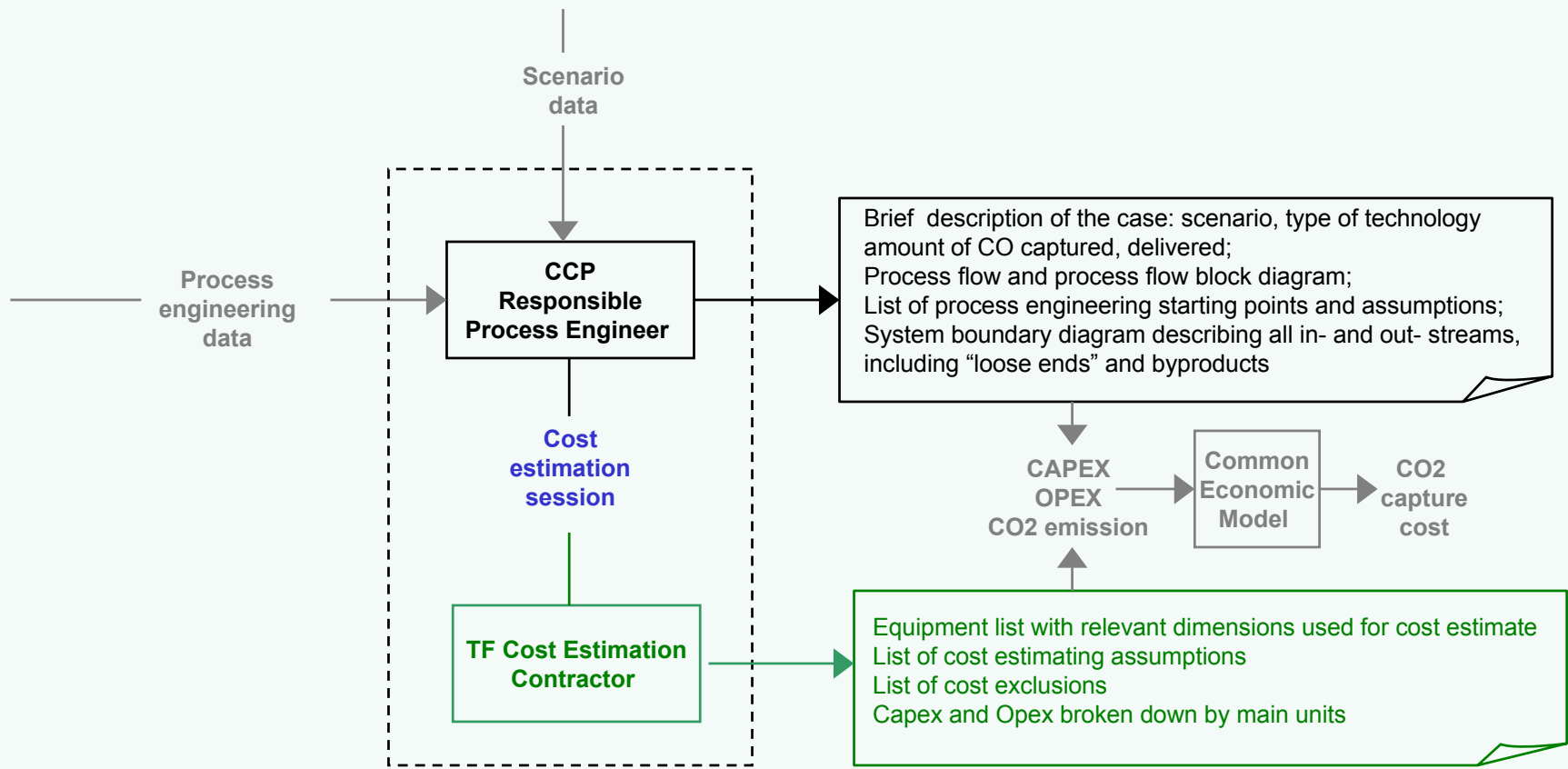*In 2002 an internal Tech Screen TaskForce was established to provide an early picture of New Capture Techs' performance*

PreComb Team

OxyFuel Team

Ext.Tech. Developers

Ext.Tech. Developers

TaskForce

PostComb Team

SMV Team

CEM Team

Task Force 2002 work

Scenario data

Process engineering data

CCP Responsible Process Engineer

Cost estimation session

TF Cost Estimation Contractor

Brief description of the case: scenario, type of technology amount of CO captured, delivered;
Process flow and process flow block diagram;
List of process engineering starting points and assumptions;
System boundary diagram describing all in- and out- streams, including "loose ends" and byproducts

CAPEX OPEX CO2 emission

Common Economic Model

CO2 capture cost

Equipment list with relevant dimensions used for cost estimate
List of cost estimating assumptions
List of cost exclusions
Capex and Opex broken down by main units

Cost Estimation challenge:
Physical scope and boundaries

- Define physical <u>Scope</u> of "Scenario-Technology case"
  - Basic plant
  - Capture Technology units
  - Other processing units
  - Site supplies and utilities
- Estimate total S-T <u>Capex</u>
  - Equipment costs
  - * cost "add-on factors"
  - = Total installed cost ("base estimate")
  - * contingency factor
  - = Total installed cost ("50/50-estimate")
- Estimate total S-T <u>Opex</u>
  - Energy, utility, supplies, manning needs (volumes)
  - * unit costs, rates, prices
  - = Total Opex

Common Economic Screening model

- <u>Multi-case</u> Scen-Tech <u>data-compiler</u> and CO2-cost <u>calculation</u> & <u>screening</u> tool
  - processed technical and cost estimate inputs from "outside"
  - not a single-case integrated engineering/ estimation/ CO2-cost model

General economic assumptions					
Scenario:					
Scenario & technology input data	Uncontrol	Baseline	NewTech 1	NewTech 2	NewTech 3
Summary economics					
Overall technology scoring					
Intermediate economics					

Economic screening criteria - CO2 avoided cost
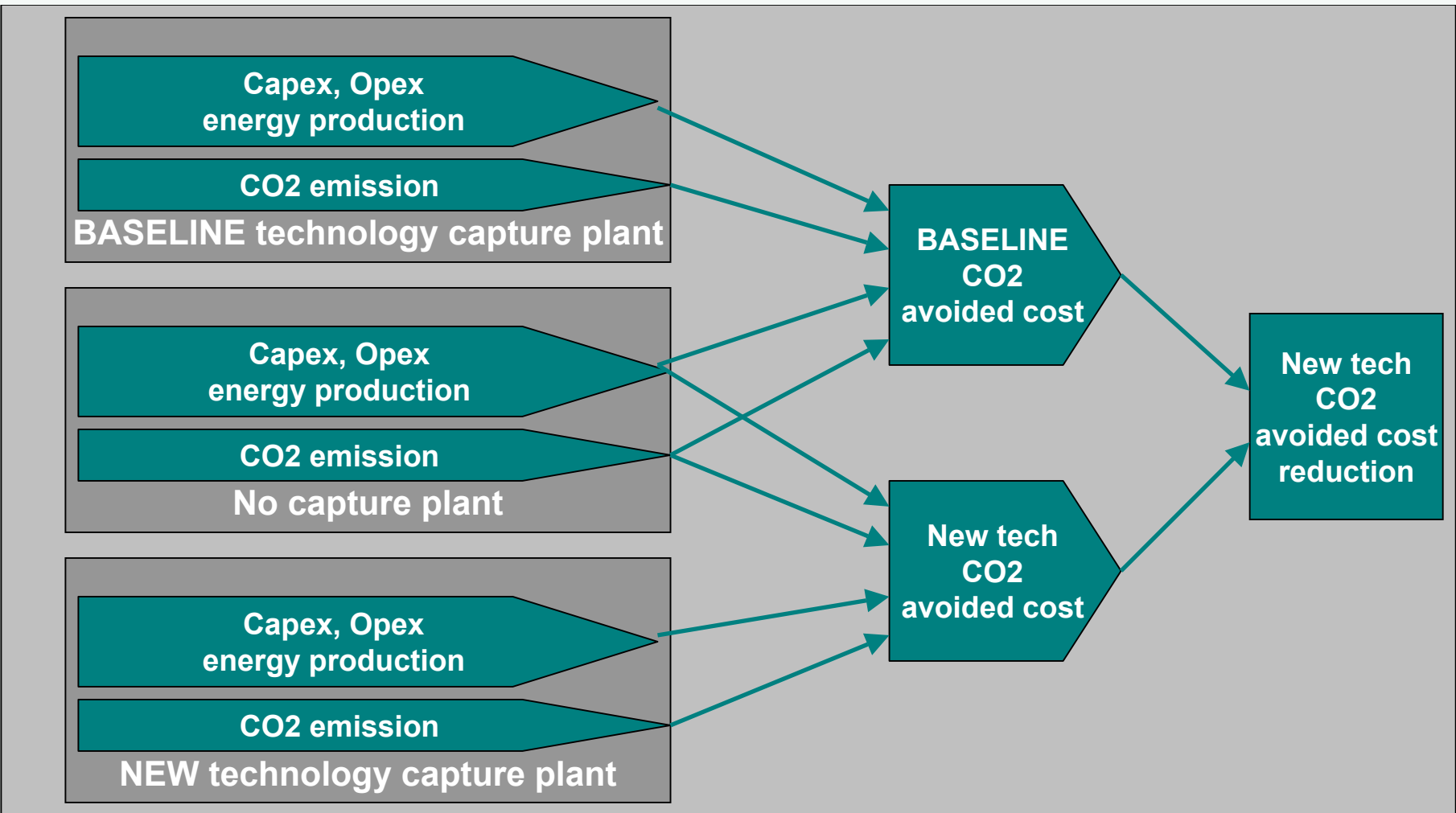
Summary work

- Final CCP reports will document performance and cost of a large package of Capture Tech. Options

- Will not make any definite selection at this stage

- Our documentation may form a new and updated basis for further Technology development efforts and priorities

No.of Tech's/ cases

| Current/ updated Scen-Tech Matrix ("Favoured" Tech's) | All Scen-Tech Cases (Internal estimates) | Summary CCP- reports |
| | "Scenario 4"Tech's (Contr. estimates) | |

Apr/ May'03   Sept/ Oct'03   Dec '03