Toward Market Launch of Coal/Biomass Coproduction Technologies with CCS

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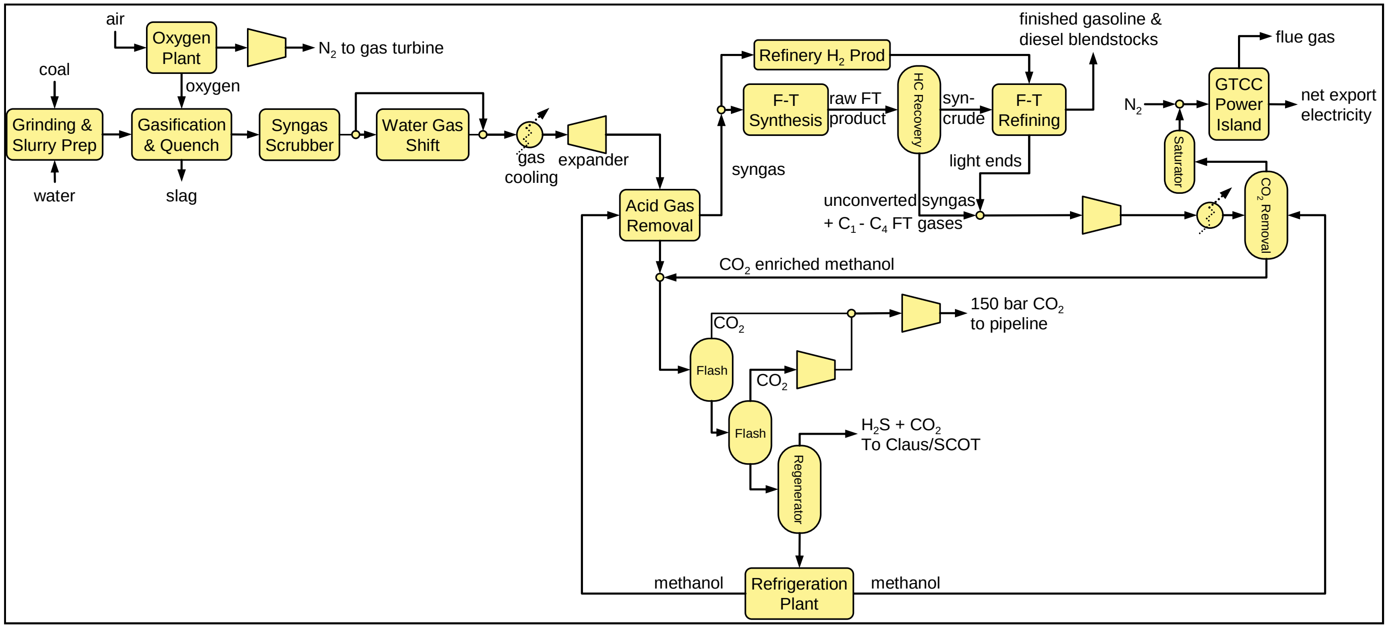
Introduction

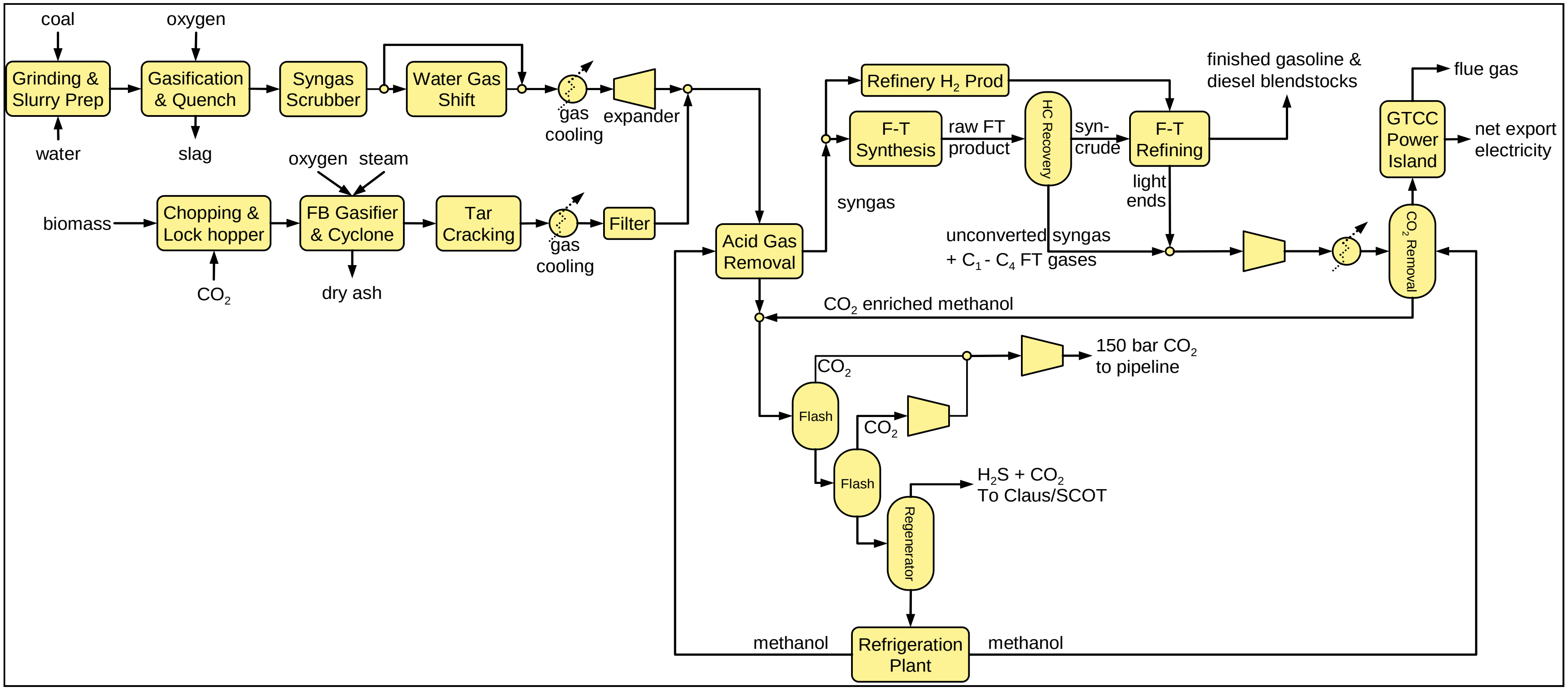
- In just-published *Cornerstone* article (Williams, 2013), I argue that coal/biomass coprocessing to make liquid transportation fuels (FTL) + electricity with CCS is key to profitably providing liquid transportation fuels and electricity under a stringent C-mitigation policy.
- In its recent report to Energy Secretary Chu (NCC, 2012), the National Coal Council recommended that the coal industry and Energy Secretary work together to find ways whereby:
  - Early-mover coal-based CO_2 capture projects linked to CO_2 enhanced oil recovery (EOR) opportunities could be financed and built to enable cost reduction via experience [learning by doing (LBD)]
  - A coal/biomass coproduction plant with captured CO_2 used for EOR be financed, built, and demonstrated at commercial scale
- This presentation suggests how both of these NCC report recommendations might be implemented

F-T Liquid Transportation Fuels + Electricity via CTL-OT-CCS



This gasification-based system (Liu et al., 2011) makes from coal Fischer-Tropsch liquid (CTL) transportation fuels in a "once-through" (OT) system configuration that provides electricity as a major coproduct. It is assumed that CO_2 is captured both upstream and downstream of synthesis for sale into the CO_2 EOR market.

F-T Liquid Transportation Fuels + Electricity via CBTL-OT-CCS



This system (Liu et al., 2011) is like CTL-OT-CCS except that biomass is coprocessed with coal in the manufacture of F-T transportation fuels and electricity.

Proposed CO_2 Capture Technology Cost Buydown Policy That Is Affordable by a Fiscally Constrained Government

- Policy proposal: The federal government invest in technology cost buy-down (via LBD) for CO_2 capture technologies linked to EOR opportunities.
- A side benefit to the government would be to generate new federal revenue streams (corporate income taxes/royalties) from new domestic liquid fuels production.
- As will be shown, the coproduction of FTL and electricity via coal/biomass coprocessing is a strong candidate for this approach to technology cost buydown…the first step of which is to provide the financing needed for a first-of-a-kind (FOAK) commercial-scale demonstration project of this technology .

Buying Down Technology Cost for Early Mover Projects Selling Captured CO_2 for EOR

- FOAK costs are estimated via "back-casting" from cost estimates for N^{th}-of-a-kind (NOAK) plants.
- Assumptions:
  - FOAK costs = 2.0 X NOAK costs (consistent w/Edwardsport IGCC experience);
  - Learning rate for capital and O&M costs = historical rate for SO_2 scrubbers (Rubin et al., 2004)—11% for each cumulative doubling of output;
  - All plants sell captured CO_2 for EOR;
  - CO_2 purchase price ($/t) at EOR site = 0.444 x (crude oil price, $/bbl) [average for Permian Basin, 2008-2010—see Wehner (2011)].
  - Crude oil price = $90/bbl and CO_2 transport cost = $10/t;
  - Subsidy must be sufficient to reduce levelized cost of electricity (LCOE) to LCOE for a natural gas combined cycle power plant venting CO_2;
  - Subsidies offered as competitively-bid grants (proportional to capture rates);
  - Subsidies financed to extent feasible from new federal revenue streams from new domestic liquid fuel production; shortfall is provided by general federal funds (GFF).

Options for Technology Cost Buy-Down in CO_2 EOR Applications

	NGCC -CCS[a]	IGCC -CCS[a]	Sup PC -CCS[a]	PC-CCS retrofit[b]	CTL-OT -CCS[c]	CBTL-OT - 5%-CCS[c]
Electric output capacity, MW_e	474	543	550	398	323	326
FTL output capacity, bbls/day	0	0	0	0	10,880	
Conversion efficiency (HHV), %	42.8	32.6	28.4	24.7	46.1	46.4
Biomass in feedstock, % HHV	0	0	0	0	0	5.2
Biomass input, 10^6 tonnes/y	0	0	0	0	0	0.18
GHGI	0.20	0.17	0.20	0.23	0.70	0.61
CO_2 to stack, lb CO_2/MWh_e (gross)	87	152	203	319	609	602
% of feedstock C captured as CO_2	90	88.4	90	90	52.2	52.4
CO_2 storage rate, 10^6 tonnes/year	1.36	3.40	4.09	3.48	2.94	2.96
Capital (TPC+OC), NOAK plant, $\$10^6$	713	1809	2098	839	2040	2050

[a] Based on NETL (2010).
[b] Based on NCC (2012).
[c] Based on Liu et al. (2011).

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[a] GHGI, the greenhouse gas emissions index is defined as the ratio of the "cradle-to-grave" GHG emissions for the system to the emissions for the conventional fossil energy displaced. The latter are assumed to be electricity from new supercritical coal plants venting CO_2 (Sup PC-V) and the equivalent crude oil-derived products.

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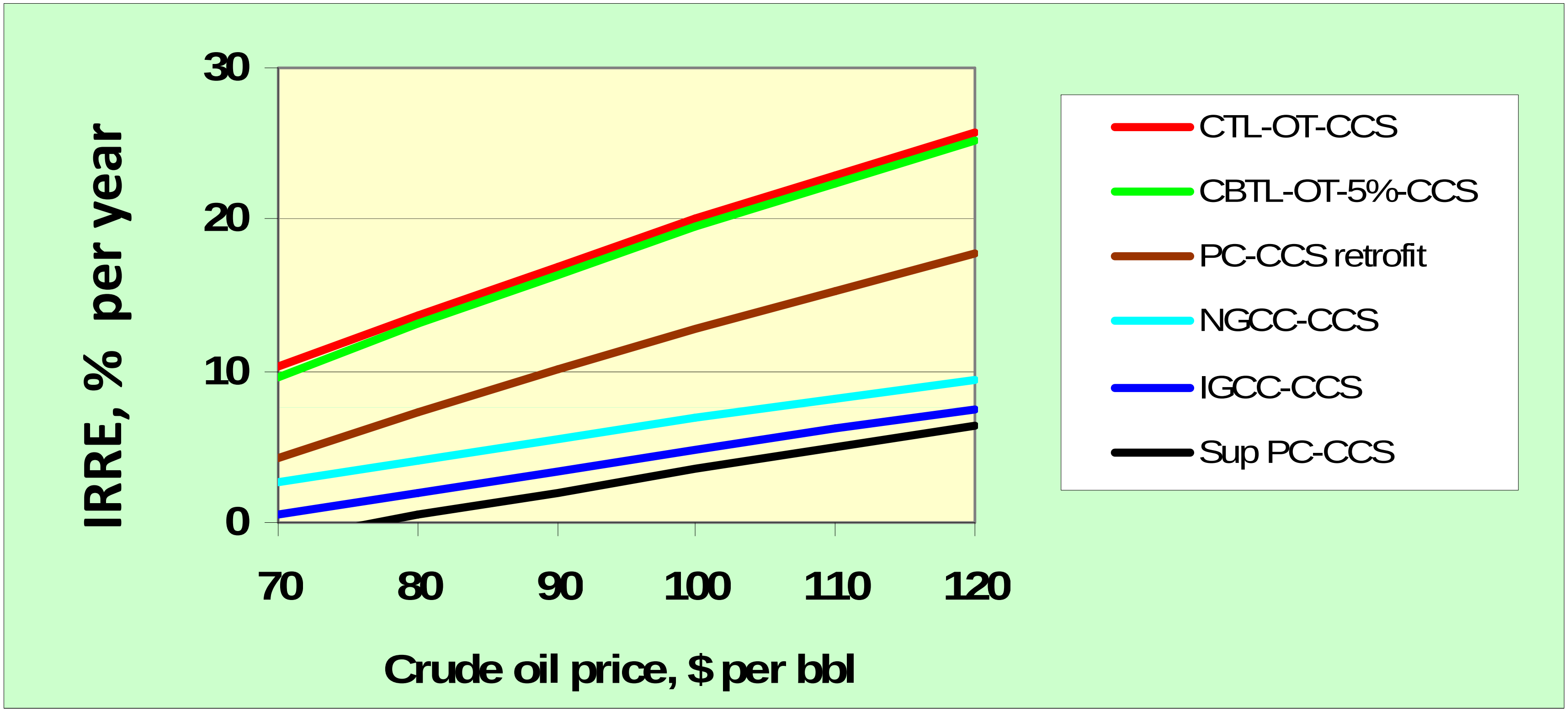
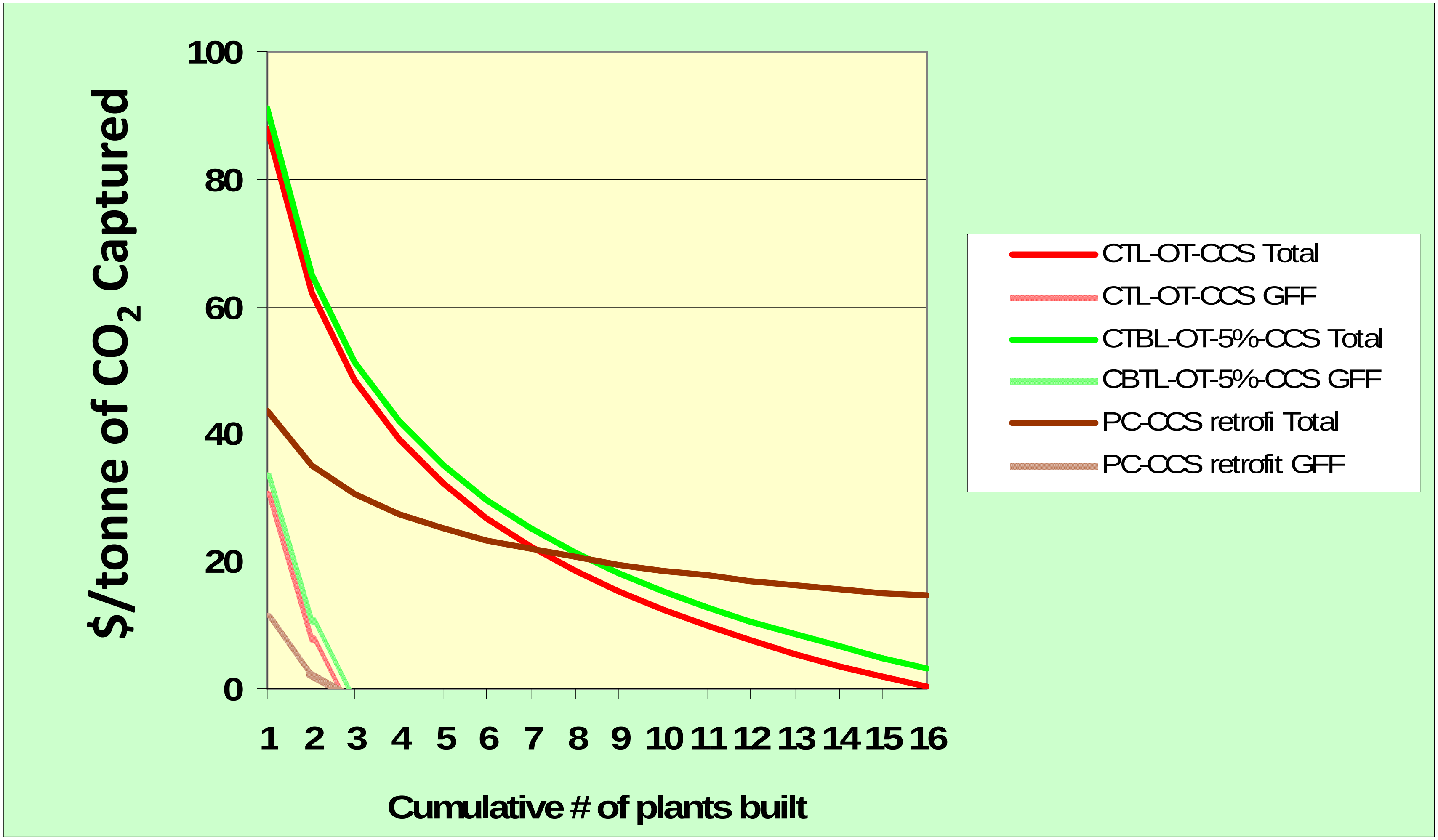
[a] All options satisfy EPA's proposed New Source Performance Standard for new power plant CO_2 emissions [(1000 lb/MWh_e (gross)] by wide margins.

<u>Screening Analysis</u>: IRRE vs Crude Oil Price for NOAK Plants



- Systems sell CO_2 into EOR markets
- Assumed prices:
  - Plant-gate CO_2 price ($/t) = 0.444*(crude oil price, $/bbl)
  - CO_2 transport cost = $10/t (nearby CO_2 EOR opportunity)
  - Coal, biomass, NG prices: $2.5/GJ; $5.0GJ, $5.4/GJ
  - GHG emissions: $0/t CO_{2e}

Total Subsidy and GFF Contribution for Cost Buydown



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After 16-18 plants have been built, coproduction options require no subsidy.

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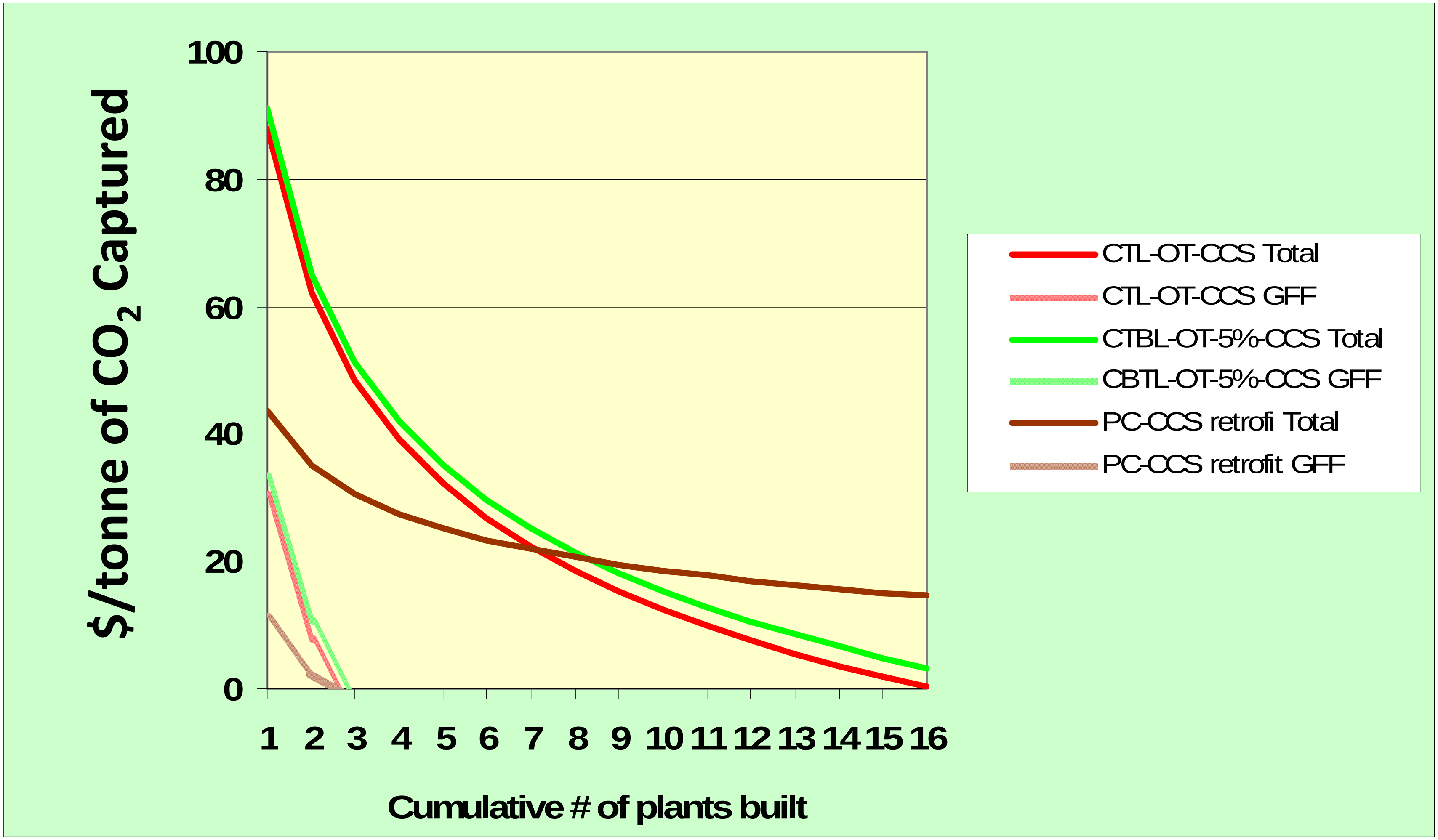

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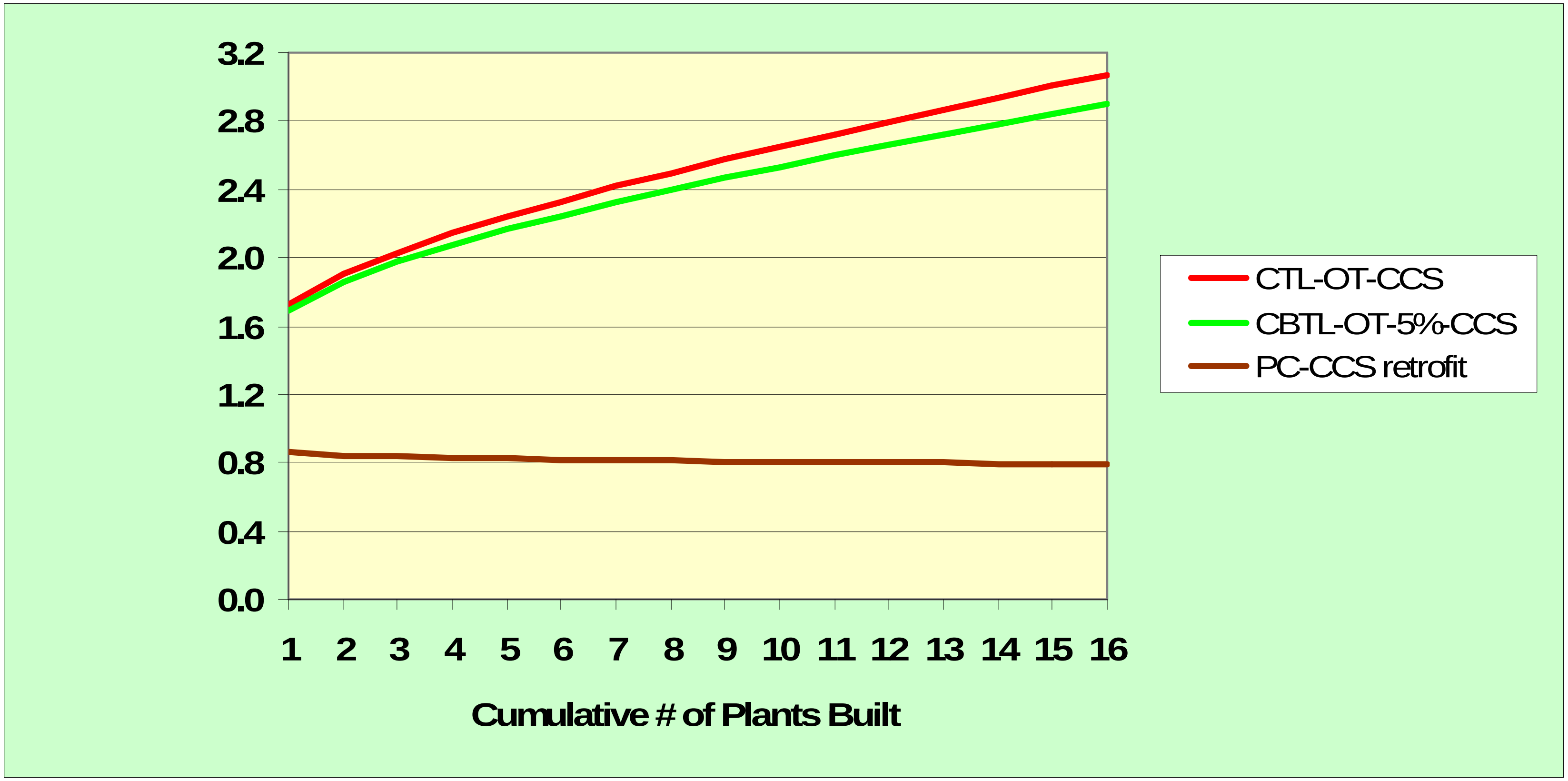
Why do required subsidies decline at different rates?

Fraction of LCOE Amenable to Learning by Doing (LBD)
(dimensionless)



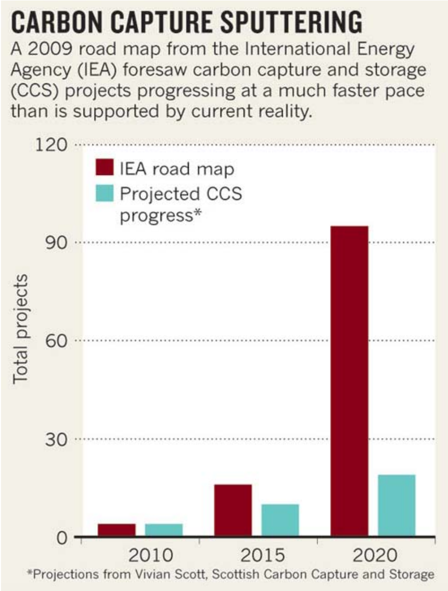
Because the fraction of LCOE amenable to LBD (capital + O&M costs) varies from technology to technology

Federal Government Perspective on Technology Cost Buydown Strategy

Buydown Subsidies & Net New Fed. Revenues for 3 Energy Options				
Energy Conversion System	Subsidy, 10^9 $		Plant for Which Cumulative New Government Revenues Net of Subsidies Become Positive	Net New Federal Revenues for 1st 16 Projects, $\$10^9$
	1st plant	**Average per plant for 1st 16 plants**		
PC-CCS retrofit	1.6	0.81	5th	6.2
CTL-OT-CCS	2.7	0.77	6th	12.4
CBTL-OT-5%-CCS	2.8	0.86	6th	11.0

Success with the Proposed Course of Action Would:

- Help get the global CCS enterprise back on track:



Source: Van Noorden (2013)

See also: Scott et al. (2013).

- Undermine the conventional wisdom that has prevented the launching of a coal synfuels industry in the US:

"Addressing climate change and ensuring domestic energy independence have sometimes proved to be contradictory goals, analysts said."

Source: Broder and Wald (2013)

- Provide a technological platform that would enable the coal industry to thrive in a C-constrained world (Williams, 2013).

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