Carbon Capture & Finance in the Agribusiness Sector

USDOE & USDA
Realizing the Circular Carbon Economy Conference
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Stanford
Steyer Taylor Center for
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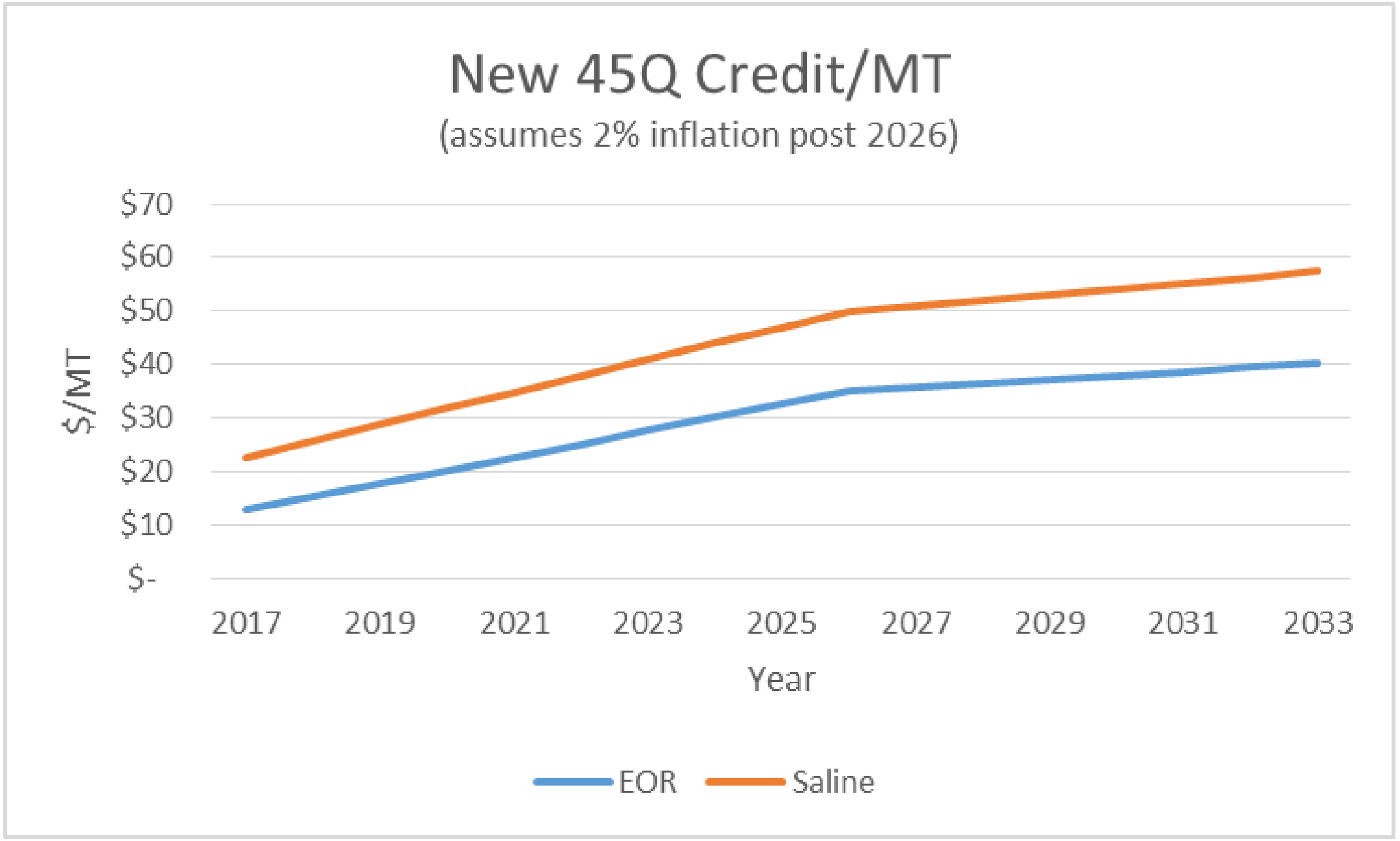
Main Points

- Technology for capture can be improved, but we have what we need now and have no excuse for delay. Examples: MDEA, Selexol, Rectisol.
- We don’t need “innovative finance.” We need business models that produce net operating profits and thus have free cash flow to repay lenders and owners. The cash flow has to be reliable, not just good on average.
- Most of focus has been on power plants. However, the ag sector and the broad energy sector are inextricably linked; and there are many cross-sectoral opportunities.
- Four things I’ve looked at:
  - Greener nitrogen fertilizers from CCS on SMRs
  - Greener nitrogen fertilizers from CCS on gasification plants
  - Capture and compression of CO2 from corn ethanol plants.
  - Wood pellets substituting for coal in power plants, even more so if power plants have CCS.
- Apologies: this will be a wide ranging talk because I believe the audience has quite a diverse set of backgrounds. Tour rather than deep dive.

Innovative Finance


New 45Q Credit/MT
(assumes 2% inflation post 2026)
$70
$60
$50
$40
$30
$20
$10
$-
$/MT
2017
2019
2021
2023
2025
2027
2029
2031
2033
Year
EOR
Saline

Other Policy Support under Consideration

- Letting **tax-exempt bonds** be used to finance carbon capture and CO2 pipeline projects—thanks to Sens. Bennet of CO and Portman of OH.
- Allowing power plants that have added CO2 capture to constitute themselves as **Master Limited Partnerships**. MLPs avoid double taxation and are now only allowed for industries that use depleting resources, excluding fossil power. Sen. Coons of DE.
- Keeping **federal loan guarantee** program up and running for carbon capture projects and perhaps expanding to CO2 long-haul pipelines.
- Changing state "renewable energy standards" to "**low-carbon energy and reliability standards**."

Before We Really Get Rolling: Double Counts

- CO2-EOR is the key to making any carbon capture business model work in the U.S. Costs are roughly same either way*, but revenues higher selling to oil:
  - CO2 sales revenues to oil = ~$25/MT plus tax credits (2026) of $35/MT = **$60/MT**
  - Sequestration in saline = (~12/MT) cost deducted from $50 credit = **$38/MT**
- No double counting going on unless you think world consumes zero oil.
  - BAU is 1 MT CO2 per MWh coal plant, plus 1 MT from 2 bbl oil = **2 MT**
  - CO2-EOR captures the 1MT CO2, injects to produce same 2 bbl oil. The two bbls oil emit 1 MT = **1 MT.**
  - CO2-EOR is about same price as other incremental barrels such as fracking, at ~$60/bbl full lifecycle production cost. A bit cheaper than tar sands. So CO2-EOR does not lower oil prices and increase demand.
- Also, biomass in non-deforestation circumstances does not create extra CO2. Example we will talk about: in tropical forests, fallen trees rot in 2-3 years and emit nearly 100% of carbon into the atmosphere, with little going to soil. So burning biomass in power plants instead of letting it rot aerobically has same emissions profile.

* "Costs roughly same": If actual capture cost = X. Pipeline transport cost to oil =~$10/MT. Injecting locally = $10/MT. X+$10 = X + $10.

“Financeable” = Generating Sufficient Cash to Repay Investment

$ Per S-Ton for Power Plant CO2-scrubber Retrofit			
Costs of Capture		**Costs of Finance**	
+$30	Section 45Q Tax Credit*	($10)	Interest on Debt
+$20	Sales of CO2 to EOR	($10)	Principal on Debt
+$50	Revenue	($15)	Total Debt Service
($20)	Operating Cost	($15)	Returns to Equity**
+$30	Operating Cash Flow	($30)	Total Payments to Finance

*Spreading the net present value of $35 for 12 years over the longer operating life of the plan & rounding for illustration.
** This is combination of a “dividend” (return on equity) and repayment of capital (return of equity), so that by the time the host coal plant is retired, equity investors will have gotten all their money back including appropriate profit rate.

Upfront Investment for 4mm tons/yr*: Repaid over Project Life

$1 billion equipment repaid

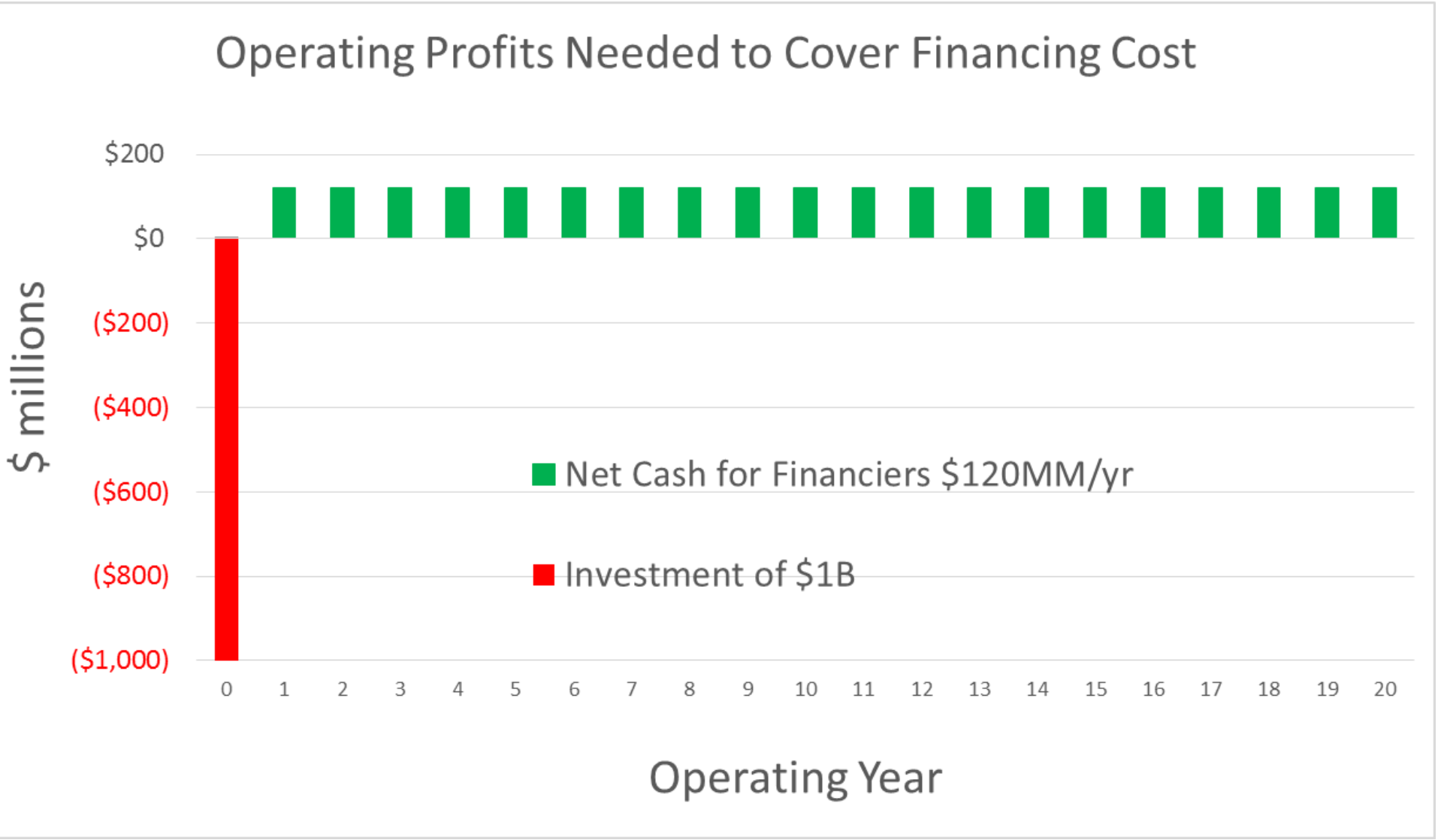
@ 12% /yr

= $120 mm/yr

$60 million minimum to bank

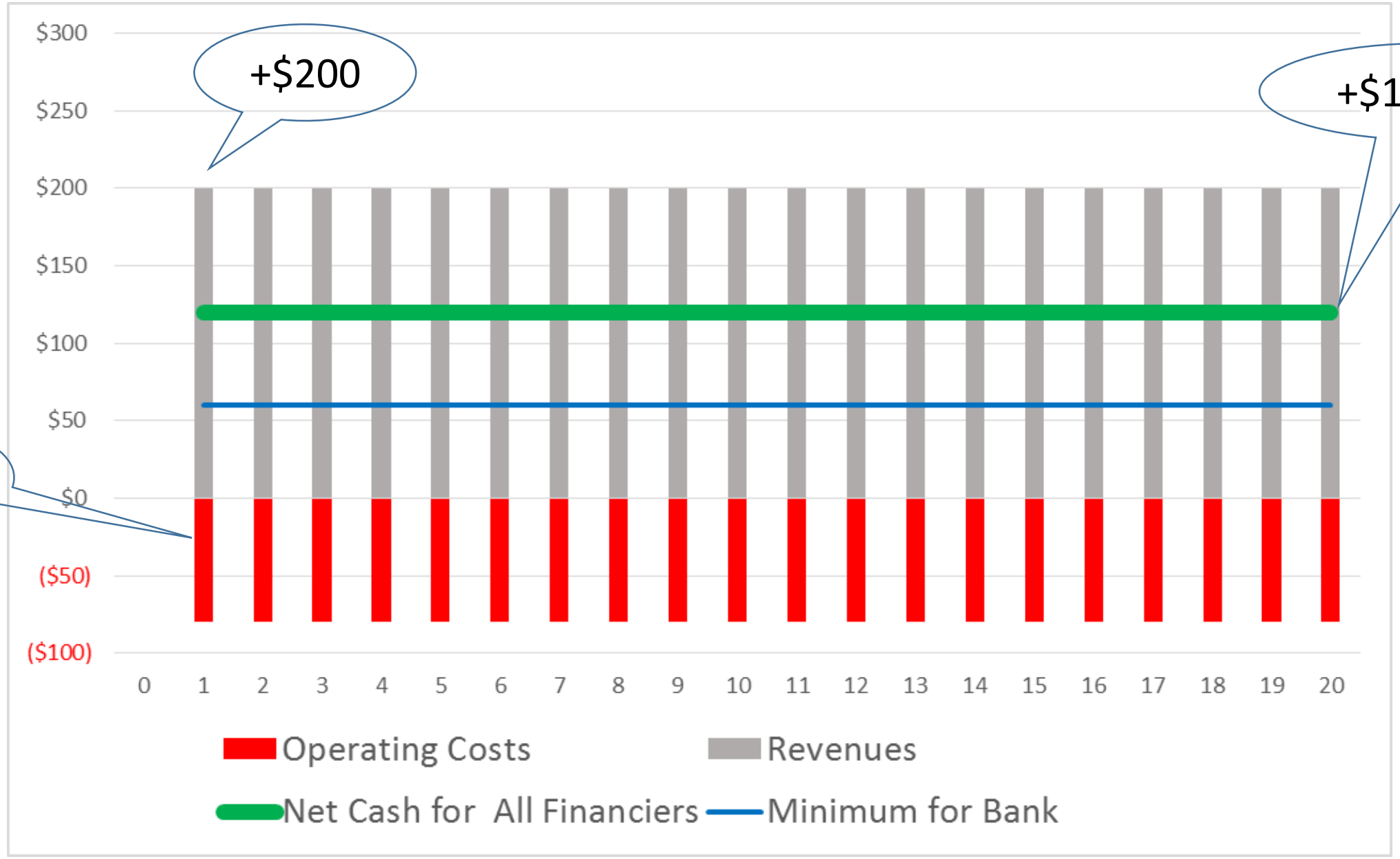
+$60 million hoped for by equity

=$120 mm/yr

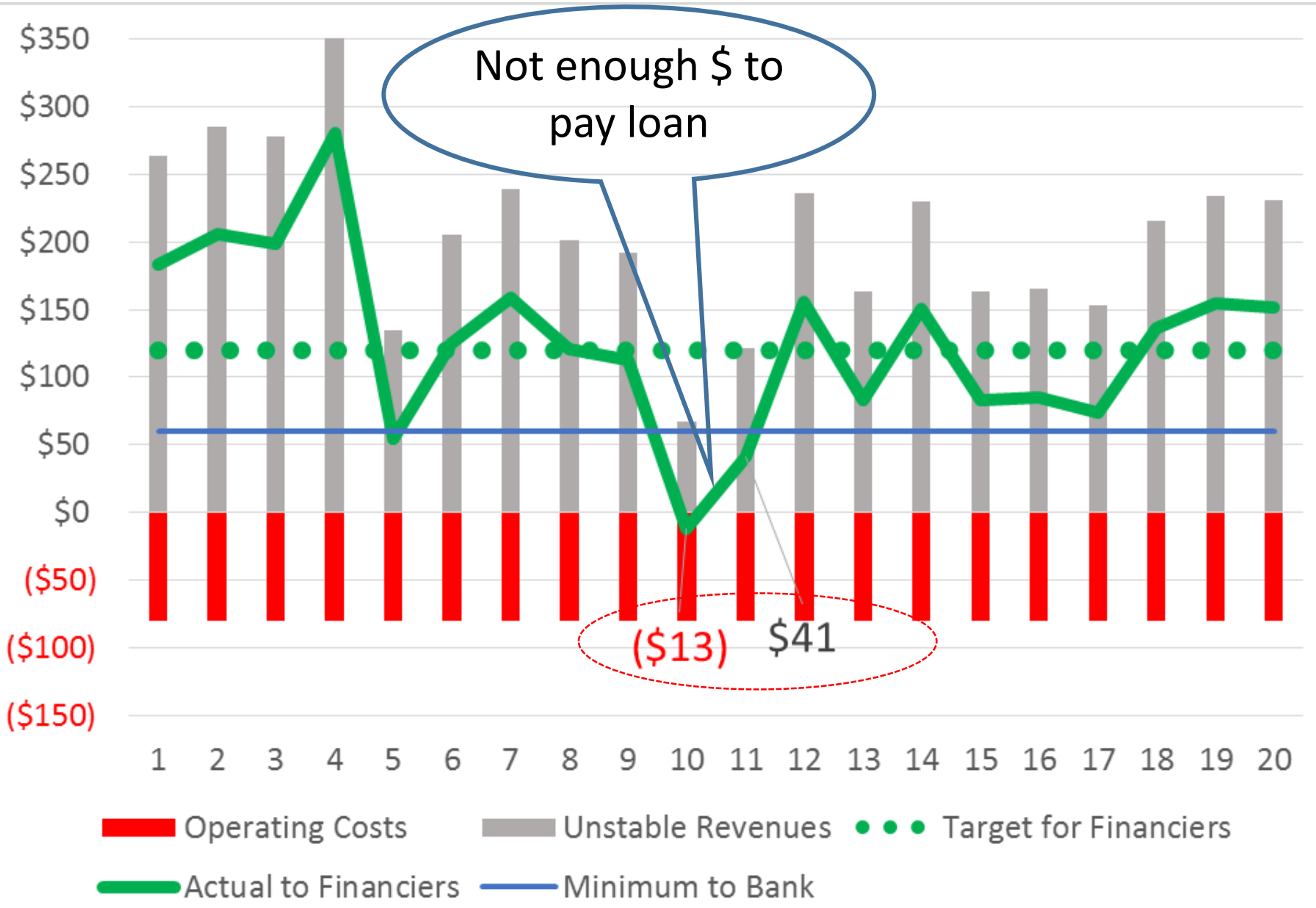


*CO2 scrubbers for coal plant w/ cost of $250 per annual 1 ton capture capacity X 4 million s-tons/yr capacity = $1B

Stable Revenues & Stable Returns Hit $120mm/yr Target



Unstable Revenues Cause Near Default



Same *average* revenues = ~$200 million, cash flow ~$120

Actual net cash flow to financiers bounces around because revenues fluctuate and costs don't change.

Two bad years in a row → $92 million shortfall on debt (needed $60/yr x 2 yrs for debt; but only got $41 plus ($13) = $92 shortfall).

Prototypical Large-scale Agriculture-Related CO_2 Reduction Opportunities that Seem to Pencil Out

None of these stand on their own without government help, but they are pretty close even with current anemic policies.

- Greener nitrogen fertilizers from CCS on SMRs
- Greener nitrogen fertilizers from CCS on coal gasification plants
- Capture and compression of CO_2 from corn ethanol plants.
- Wood pellets substituting for coal in power plants, even more so if power plants have CCS.

Ammonia and Urea from Natural Gas w/ CO_2 Capture

- Need source of pure hydrogen gas to react with nitrogen to make NH_3 (ammonia)→ every ammonia plant has a "hydrogen plant." Called Steam Methane Reformer (SMR). SMRs are also on front-end of every oil refinery.
- Make H_2 by putting methane (CH_4) in a pressure cooker with steam H_2O.* End up with CO_2 and H_2. CO2 is emitted except to extent used in further processing to make urea.
- Below I reviewed International Energy Agency study on done by Foster Wheeler on costs of adding better carbon capture to Steam Methane Reformers. I adjusted European costs for U.S. levels, and recalculated incremental cost per MT captured.

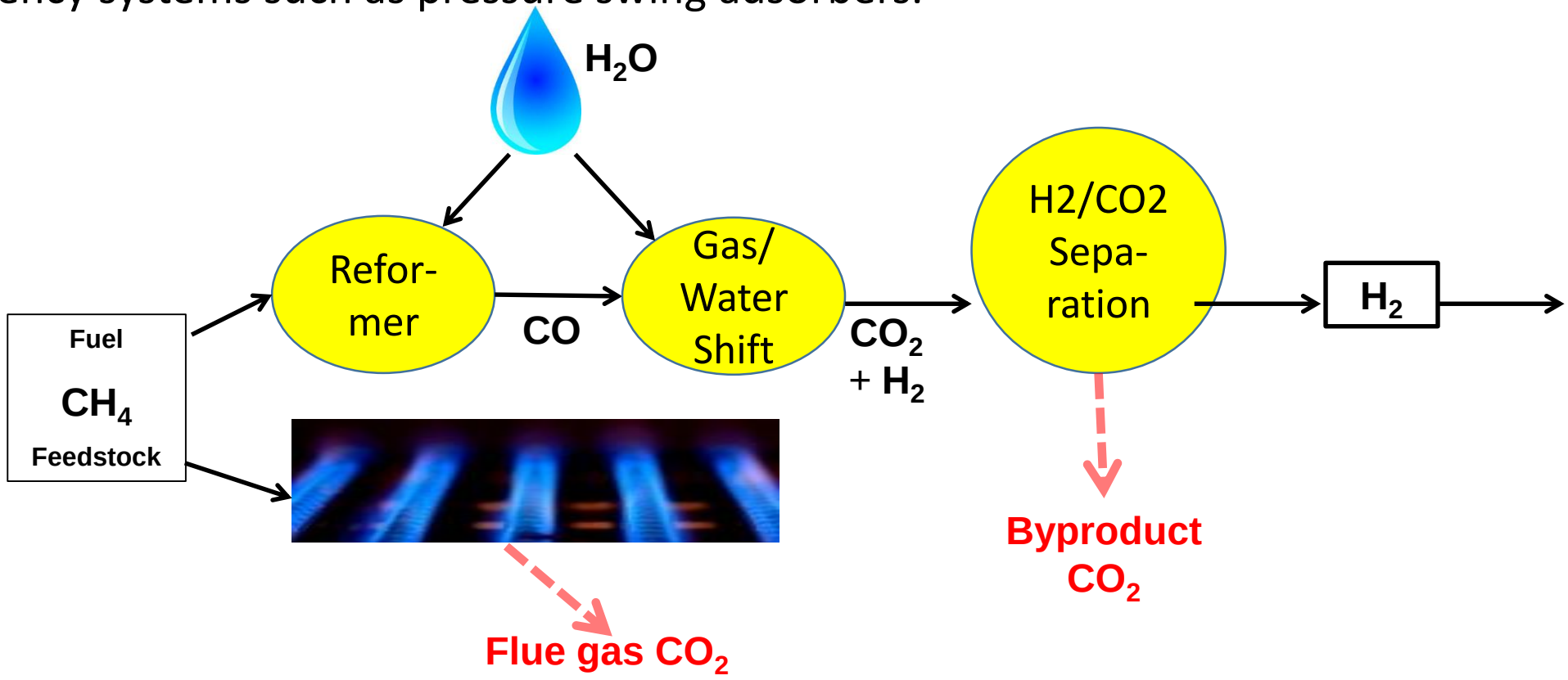
	Changes Between European Situation and U.S. Situation			**Avoided Cost per MT/CO2: IEA vs. "U.S.-adjusted "**	
	Gas/ MMBTU cheaper in US	Elec. $/MWh cheaper in US	Sequestration cost in Europe, vs. CO2-EOR sales revenues in U.S.	50% Capture $/MT	90% Capture $/MT
European Costs and Results	$7	$97	($12) cost	$56	$122
US Costs and Results	$3	$40	$25 revenue	$4	$85

*$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$

CCS at Steam Methane Reformer Hydrogen Plants

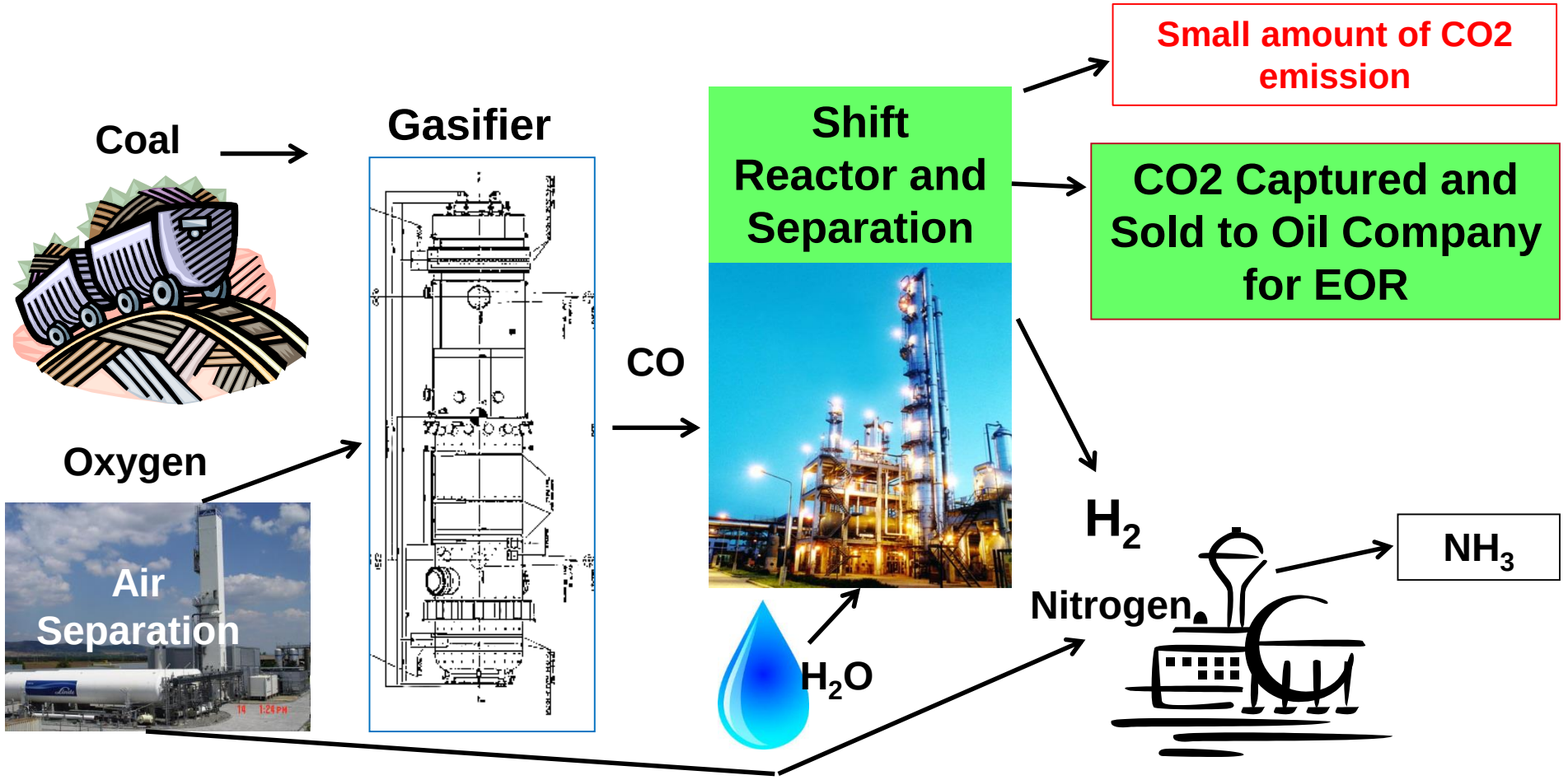
Flue gas CO2 from the burners used to generate process heat can be treated with the same type of amine systems used for power plant flue gases.

Byproduct CO2 is available after H2/CO2 separation; separation is done via high efficiency systems such as pressure swing adsorbers.



Gasification to Produce Hydrogen as Feedstock for Chemical Plant (e.g., Ammonia or Urea)

[Gasifier plants use cold methanol or propylene glycol for capture]



Ethanol Plants

- Bioethanol was not designed to be CO_2 friendly. Was designed to avoid importing oil.
- There are dozens of lifecycle analyses of CO_2 impact of ethanol vs. gasoline—I haven't found a pair that agree.
- But, pure CO_2 comes off fermentation tanks, with estimate of "capture" cost being about $20-25/ton, basically for dehydration and compression. Theory aside—low hanging fruit.
- Options are:
  - "Passive sequestration" such as injection in saline aquifers. Higher tax credits but cost of injection.
  - Sale to oil producers, with high cost of transportation and lower tax credits, offset by sales revenues from the oil companies.

Current and Upside Economics: Ethanol

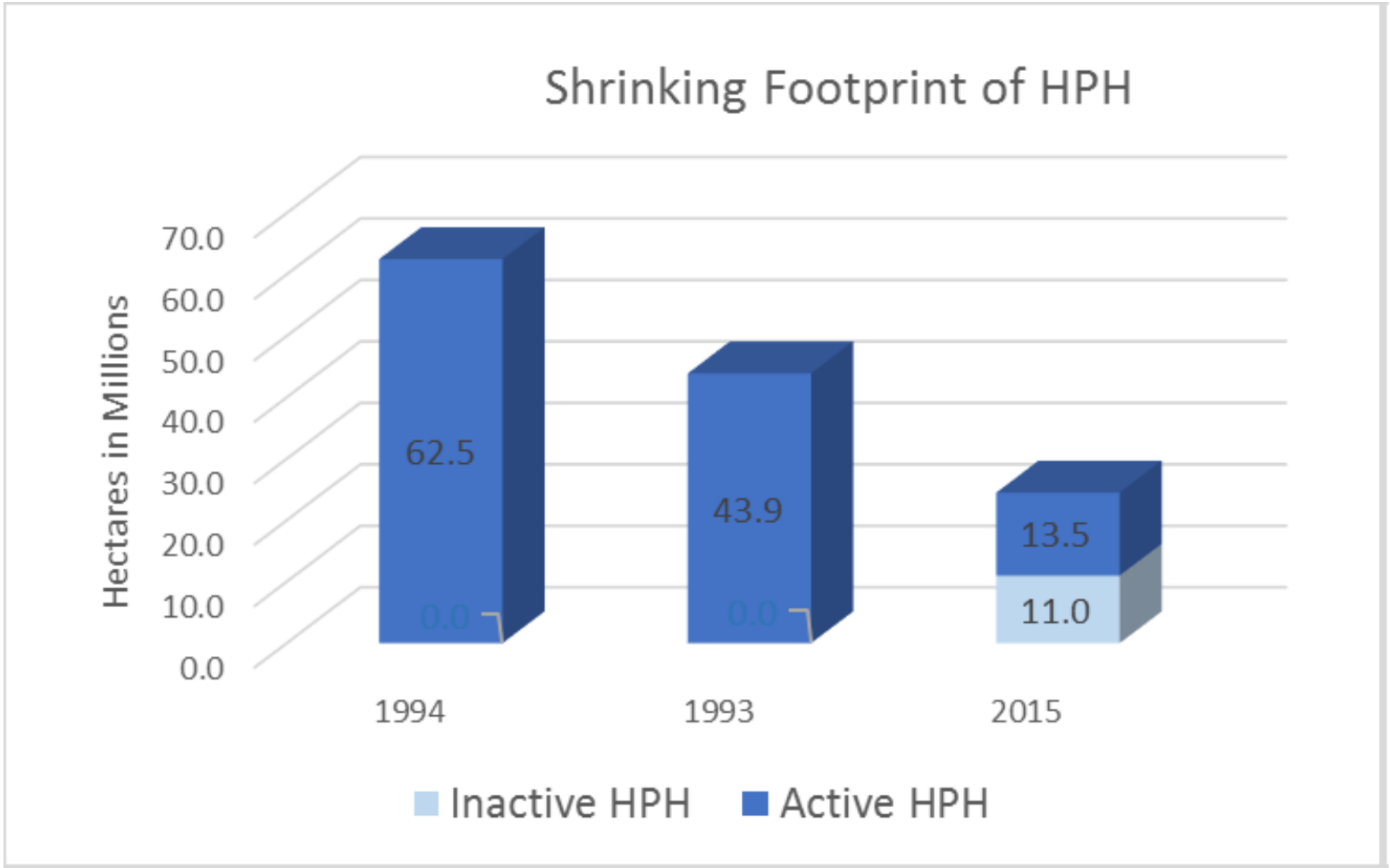
	Passive Sequestration	CO2-EOR Now	CO2-EOR High Oil Price Upside
Capture/s-ton	($20)	($20)	($20)
Sequestration Cost	($15)	--	--
Pipeline to Oilfield		($15)	($10)*
Sales to Oilfield		+$20	+$30**
Tax Credit (2020)	+$29	+$18	+$18
Total	($6)	+$3	+$18

*Federal action to lower pipeline finance costs

**Oil prices $90/bbl vs. $60/bbl

Waste Wood → Pellets → Coal Substitution

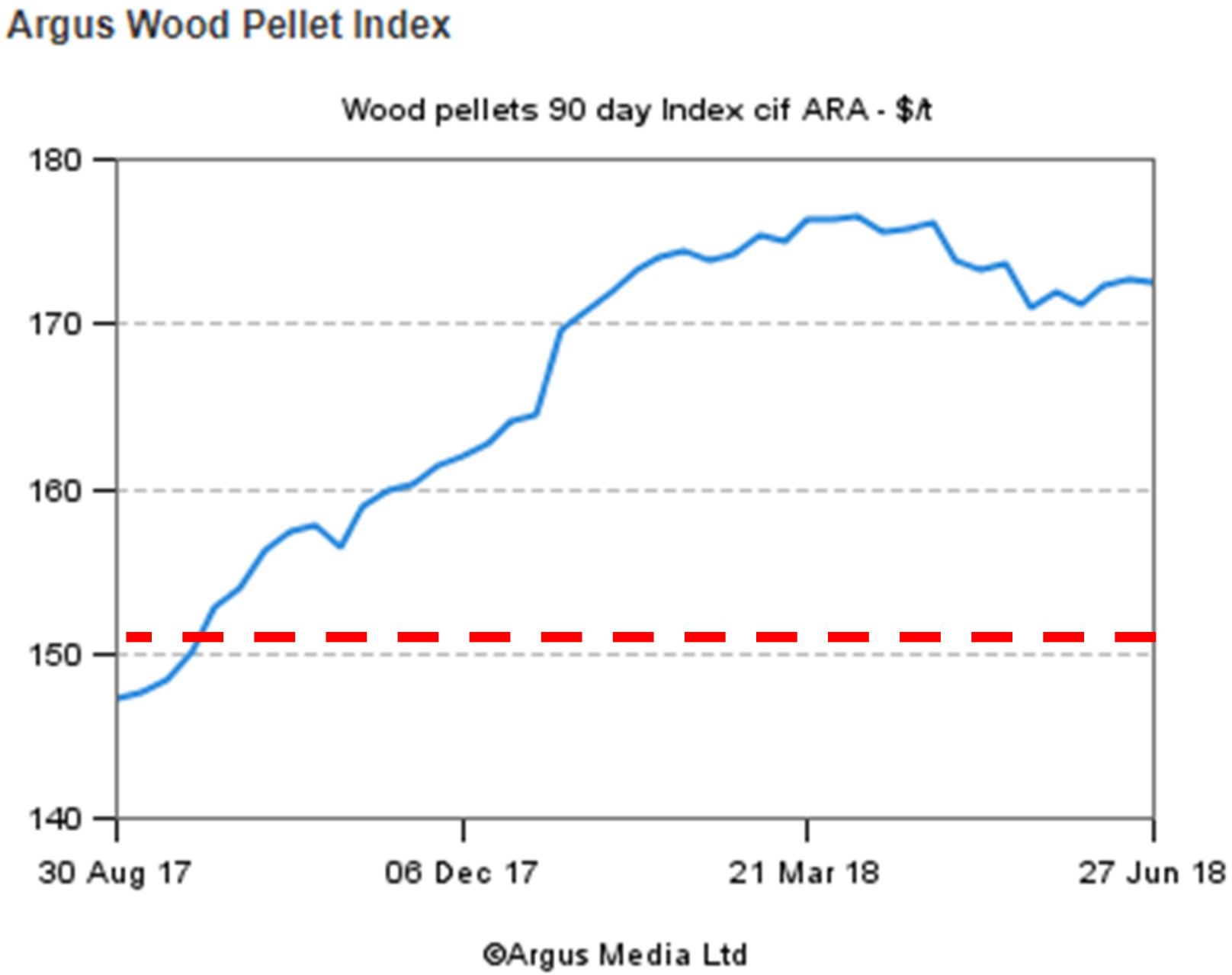
- My brother and I are working on a project to take waste wood from Indonesian sustainable harvest natural forest concessions, make wood pellets, sell to Japan and Korea.
- Hope is to gain extra incremental revenues for the forestry concessions to keep them from being torched and turned into palm oil plantations.
- 900,000 hectares of concessions x 750 MT CO2/ha = 0.7 billion tons CO2 emitted if burned.
- If 100% of typical annual woodwaste volumes were converted to pellets and sold to Korea/Japan, we could avoid approximately 2 million tons CO2 per year of coal plant emissions.



1994 to 2015 reduction would be approximately 6 years of US emissions, ~29 billion MT

Mothballed Pellet Mill—Could be Revived

Price vs. Cost Estimate



Major Obstacles to Saving Forests

- Indonesian government charges same taxes for perfect logs of large diameter suitable for plywood or clear-grained lumber as for damaged trees too small for processing.
- Governments (such as California) that have “forest carbon credit” programs get local peoples’ hopes up, but don’t really do deals.* They insist on dealing government-to-government under “jurisdictional” protocols. But no rational business invests money to avoid carbon emissions on the strength of getting money from Indonesian provincial officials.
- Much easier for a biomass company to get wood from plantations of monoculture species like acacia or calliandra, rather than to go through the hassles of working with natural forestry concessions.

California was a founder of the Governors’ Climate and Forests Task Force in 2008. Look at the website. https://gcftf.org/ **California has never paid a single dollar to a tropical forest jurisdiction for saving forests.** After a full decade of meetings re *“the potential for international offset credits generated through approved sector-based crediting programs issued by a subnational jurisdiction in a developing country”* nothing has happened.
https://www.arb.ca.gov/cc/capandtrade/sectorbasedoffsets/sectorbasedoffsets.htm

Is it Worth the Mosquito Bites? Yes*

*Except for my brother who has now had two different versions of dengue fever. Please use DEET and don't wear tank tops.

Conclusion

- There are cross-sectoral opportunities to create financeable businesses at intersection between ag and energy.
- Because electricity and cars are the big emitters, much less focus has been given to those opportunities—even though they may be cheaper.
- The opportunities are not susceptible to “big picture” blather. Each opportunity is more like house-to-house fighting.
- The opportunities are still worthwhile simply because the stakes are so high.
- Government and NGOs are doing a lot of good. The opportunities I mentioned have been and are being helped by USDOE, USDA, World Bank, Asian Development Bank, the UK DFID. And NGOs such as The Nature Conservancy and The Borneo Initiative