ECONOMICS OF PHOSPHORUS RECOVERY

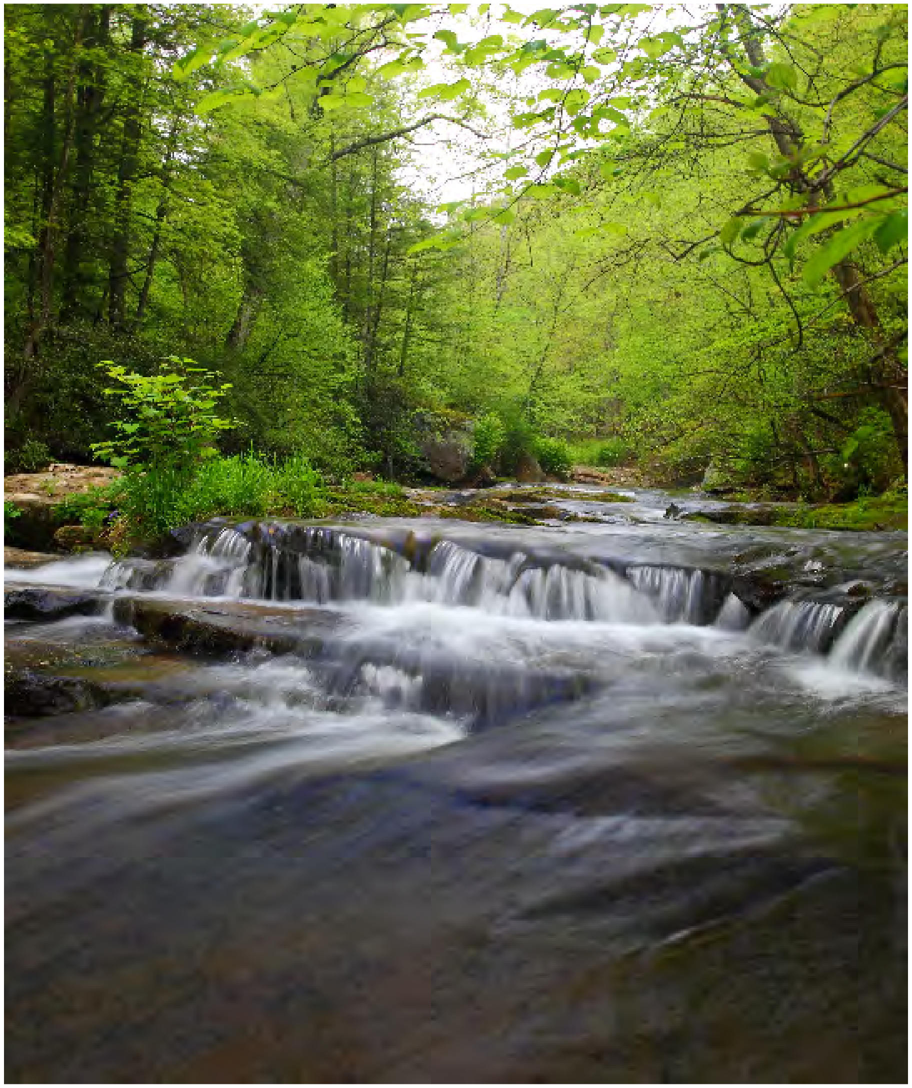
Dave Kinnear

Gary Grey, Mario Benisch, JB Neethling, David Vaccari

HDR

INTRODUCTION

- Environmental Science – Stockton State College
- Environmental Engineering – Penn State, Lehigh, Utah
- Technology-Driven Engineer
- Environmental Engineering – Gent University, Belgium
- Economics ruined engineering career



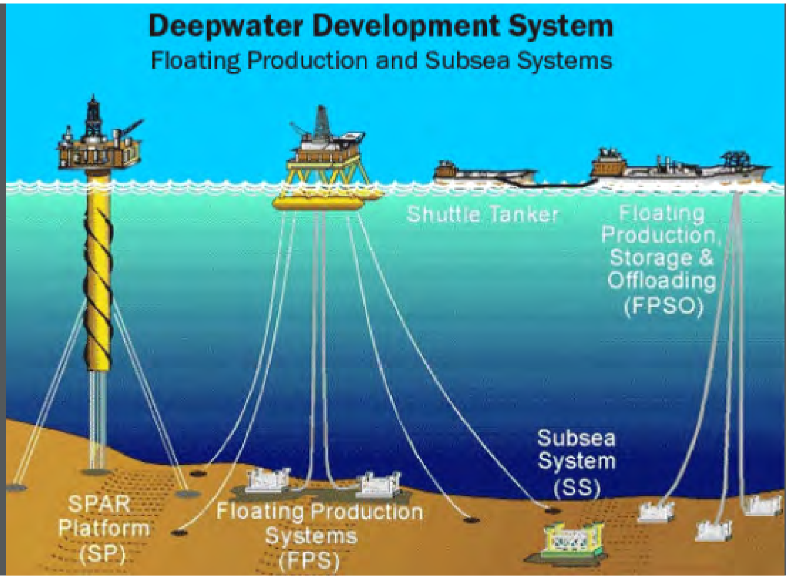
01 PHOSPHORUS AND DRIVERS

PHOSPHORUS

- Essential to life…yada yada
- Production – 158 Mt/yr (USGS)
- Reserves - 16,000 Mt (USGS 2010)
- Reserves – 60,000 Mt (IFDC)
- Resources – 290,000 Mt (IFDC)

- Technology and Price convert Resources into Reserves in time.

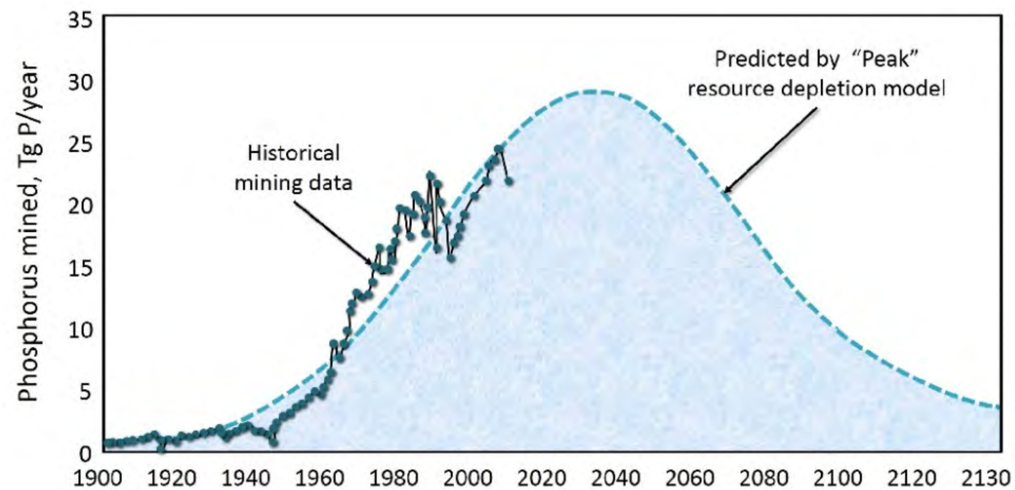
- Why prospect for 300 years in future?

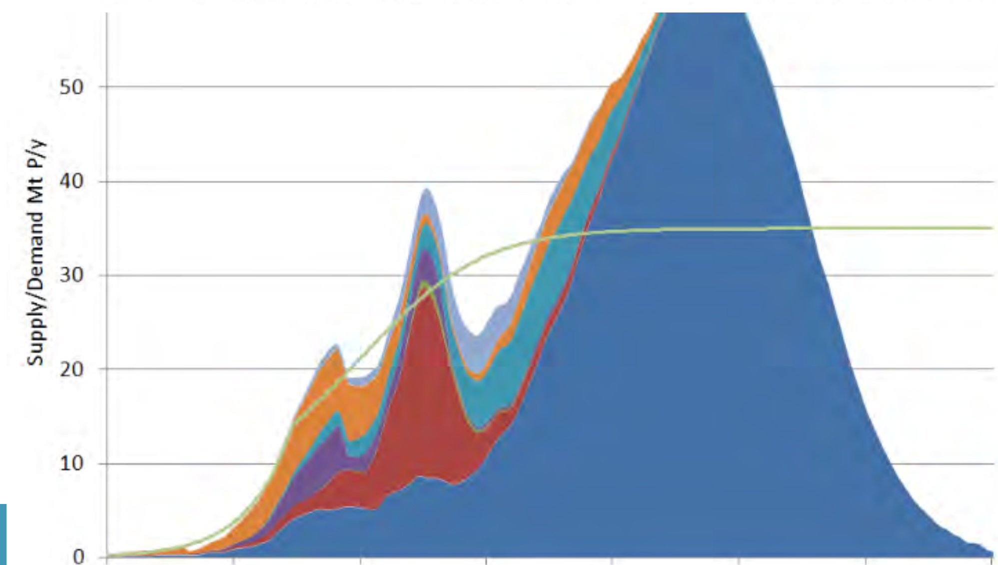


PEAK PHOSPHORUS

- Same concept as peak oil – we are soon going to reach a supply-side plateau.
- Peak oil will occur – but likely due to reduced demand as renewable sources become available at lower price (without subsidies).

- Will something similar happen for P? P has no substitute – or does it?



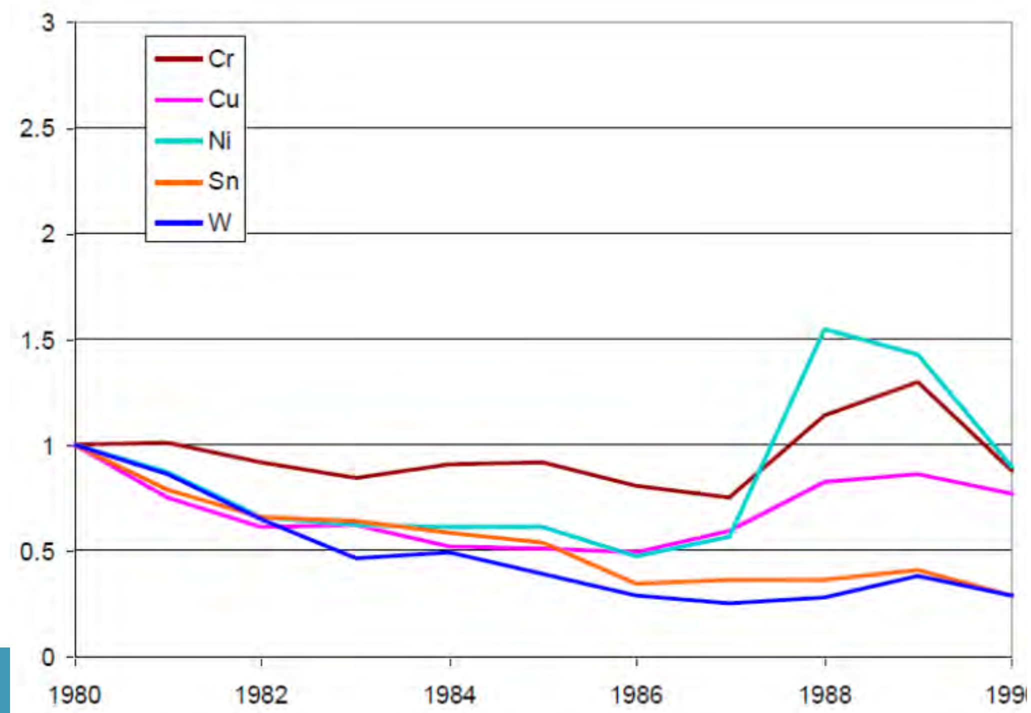


02 THE BET

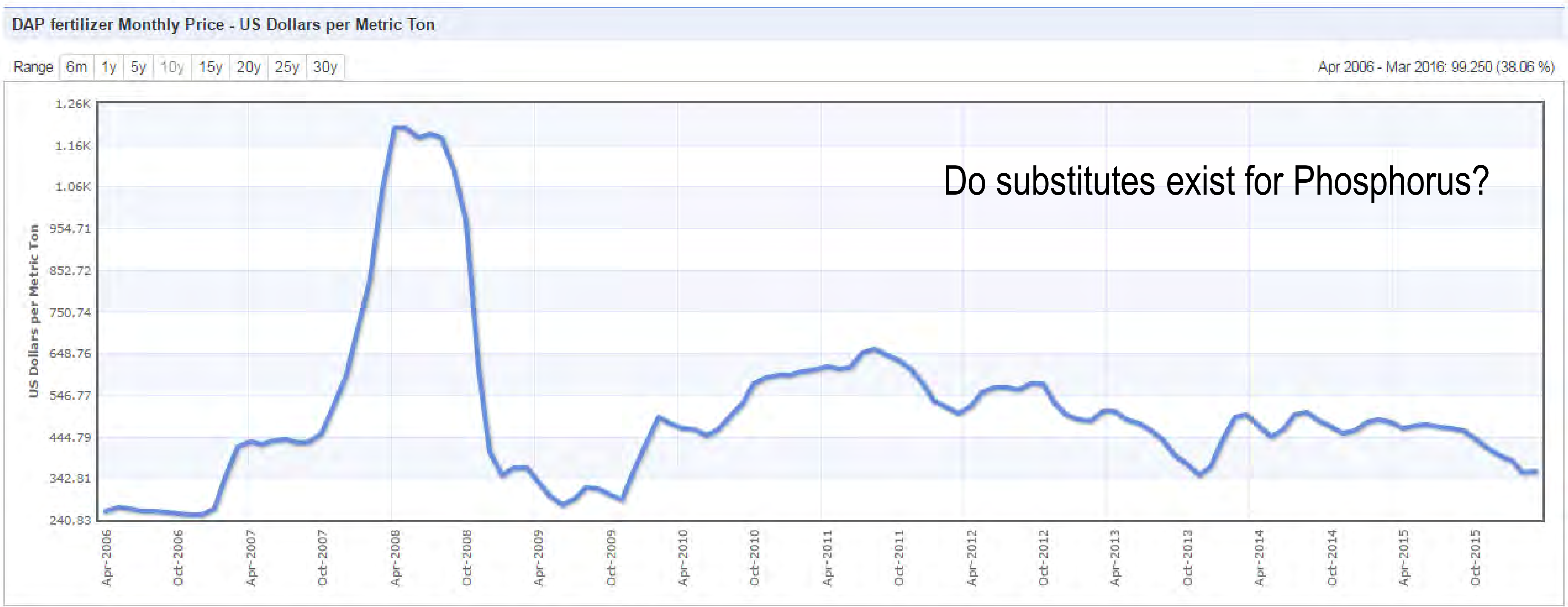
SIMON-EHRLICH WAGER

- Ehrlich – Malthusian Stanford ecologist. *Author of Population Bomb*.
- Simon – Business Professor at Maryland

- Bet whether a basket of commodity metals would increase or decrease in real dollars over the 1980s decade.



DIAMMONIAUM PHOSPHATE PRICE



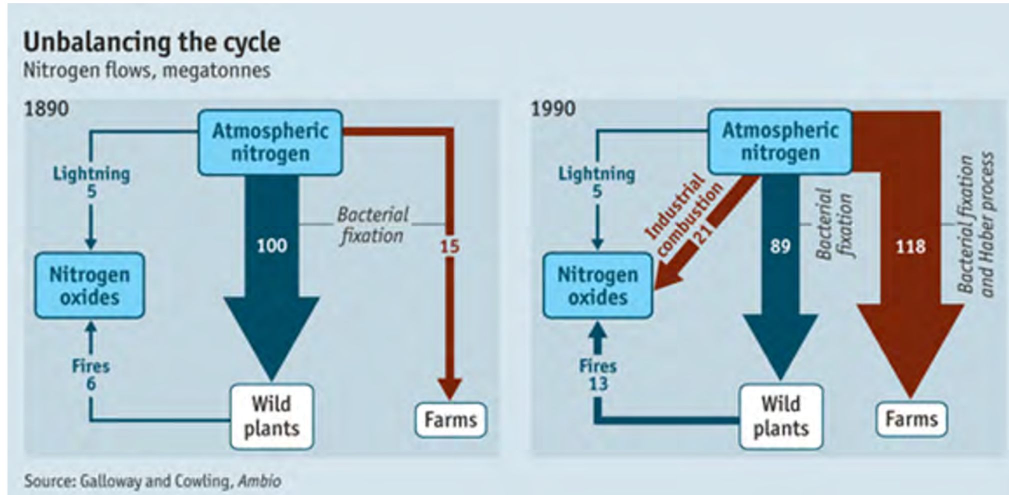
Description: DAP (diammonium phosphate), standard size, bulk, spot, f.o.b. US Gulf

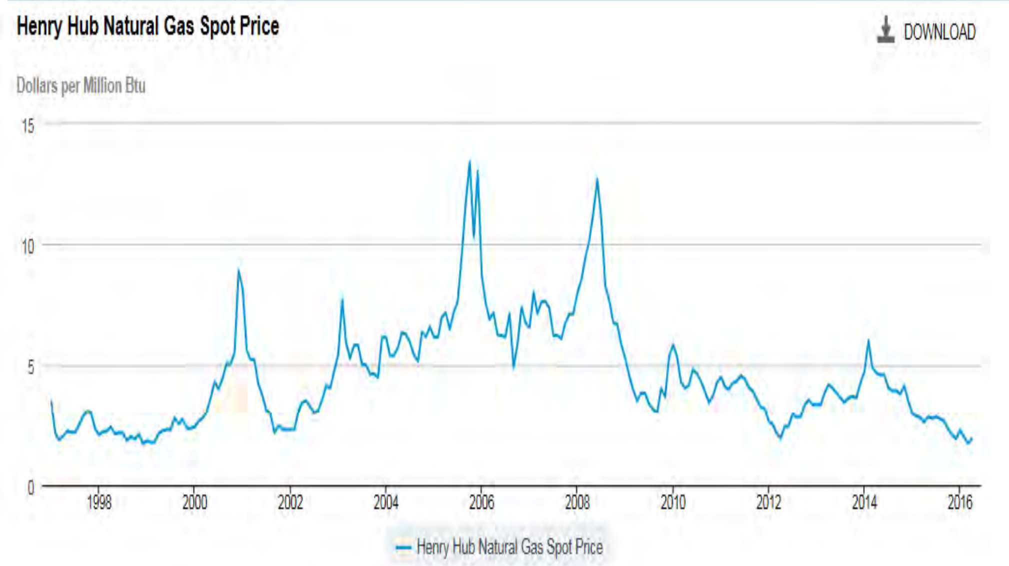
03 COMMODITY PRODUCTION

WWTPS COMPETE WITH COMMODITY PRODUCERS

- Nitrogen – ammonia (HB)
- Phosphorus – MAP (Mining)
- Energy – Methane or Electricity (Fracking, Power, Solar)

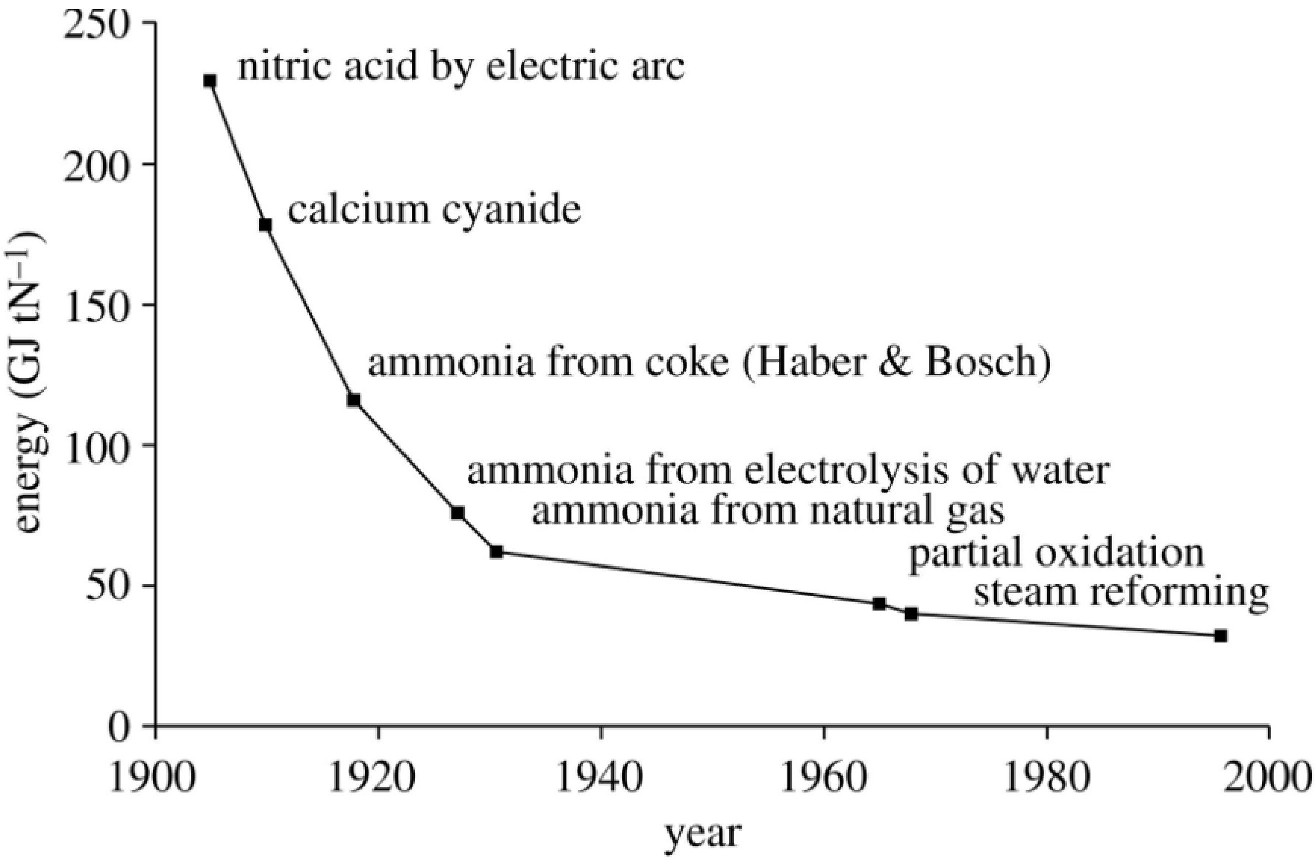
- More unit capital required due to limited economy of scale

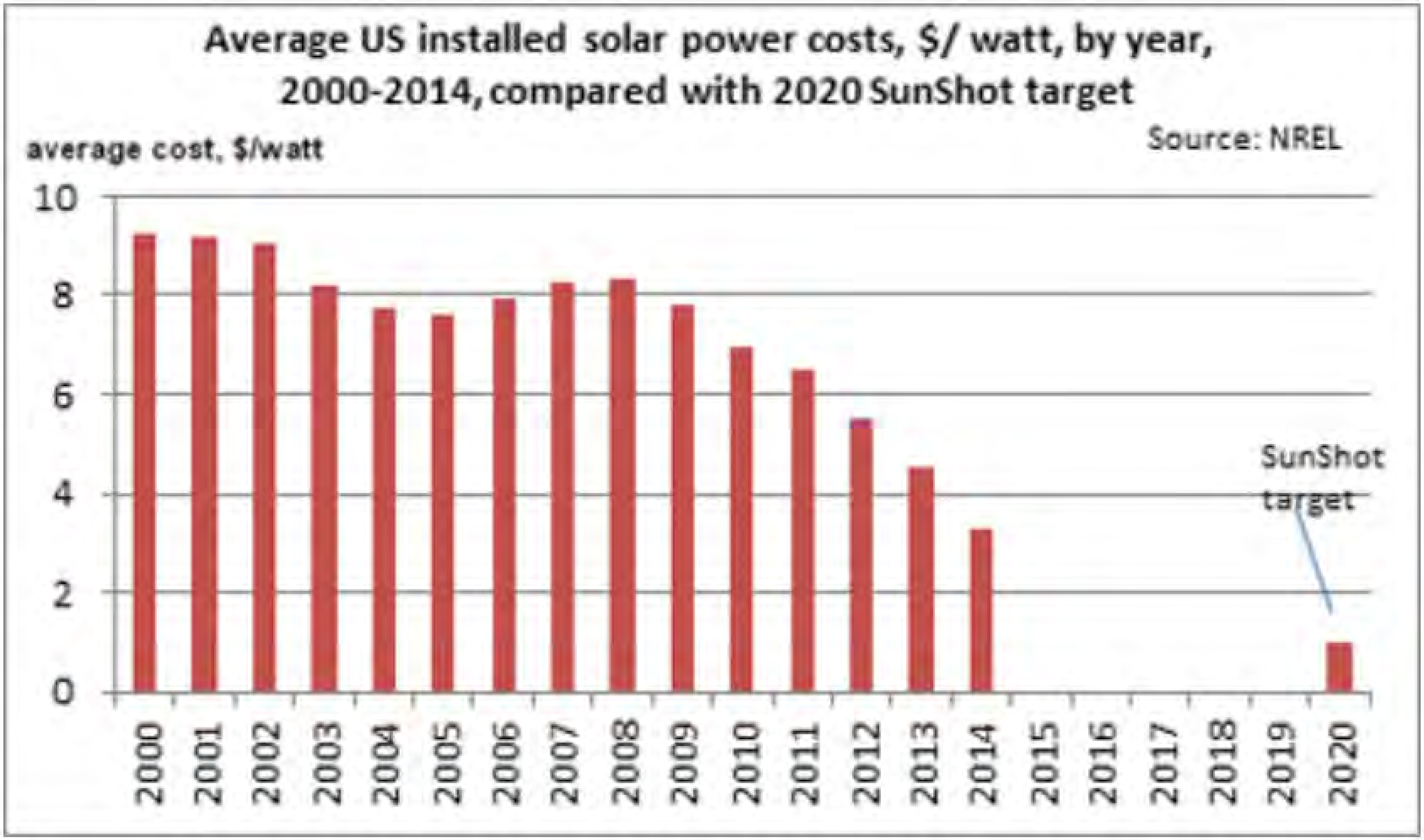




03 TECHNOLOGY CHANGE

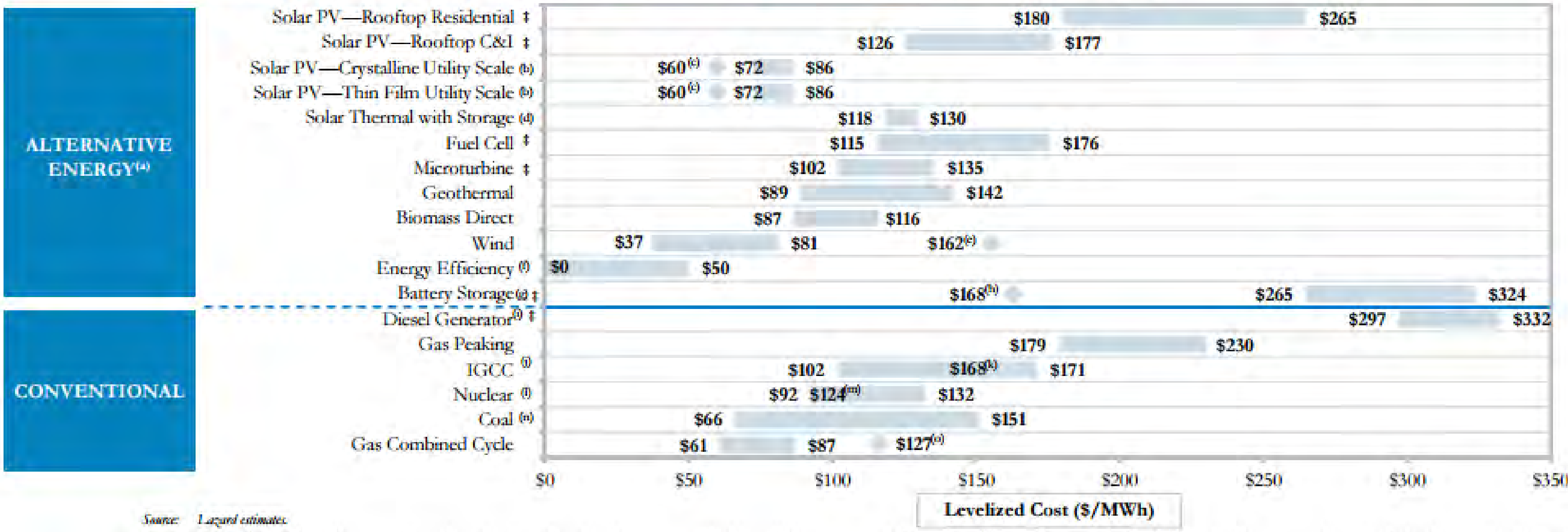
ENERGY REQUIRED FOR N FIXATION




Average US installed solar power costs, $/ watt, by year, 2000-2014, compared with 2020 SunShot target
average cost, $/watt
Source: NREL
10
8
6
4
2
0
SunShot target
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020

Unsubsidized Levelized Cost of Energy Comparison

Certain Alternative Energy generation technologies are cost-competitive with conventional generation technologies under some scenarios; such observation does not take into account potential social and environmental externalities (e.g., social costs of distributed generation, environmental consequences of certain conventional generation technologies, etc.) or reliability-related considerations (e.g., transmission and back-up generation costs associated with certain Alternative Energy generation technologies)



Source: Lazard estimates.

Engineering phosphorus metabolism in plants to produce a dual fertilization and weed control system

Damar Lizbeth López-Arredondo & **Luis Herrera-Estrella**

Affiliations | **Contributions** | **Corresponding author**

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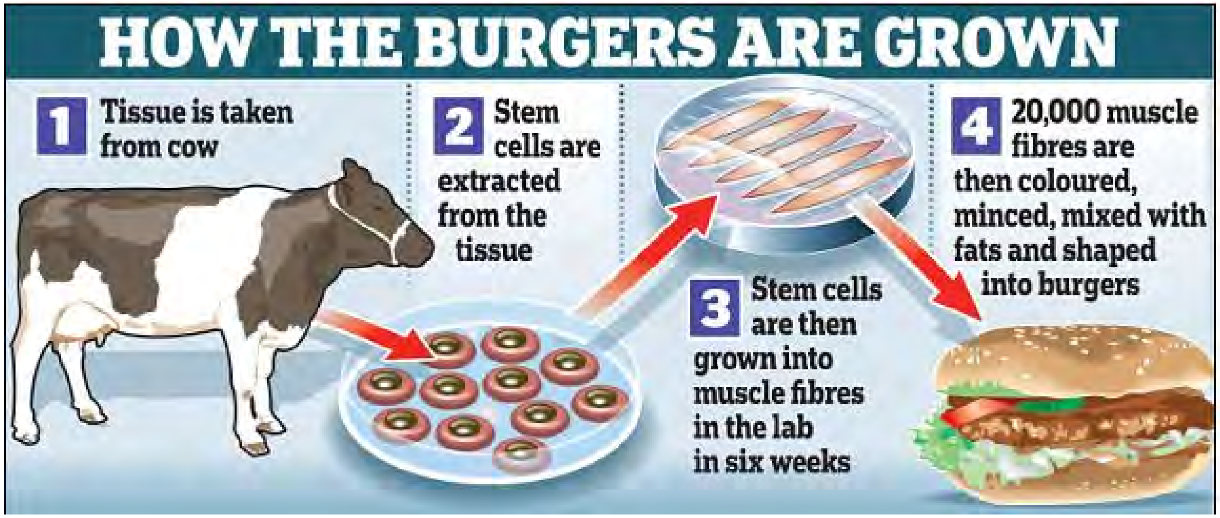
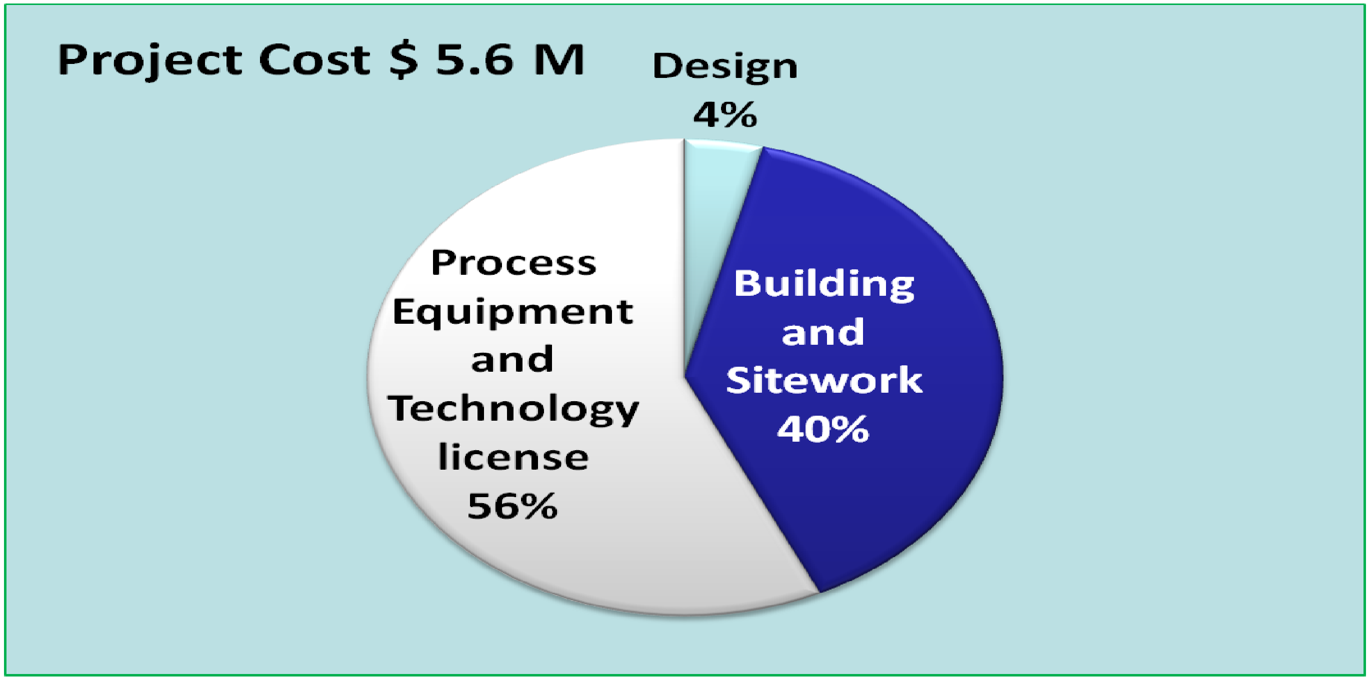


04 HRSD NANSEMOND PLANT

Struvite Facility Cost



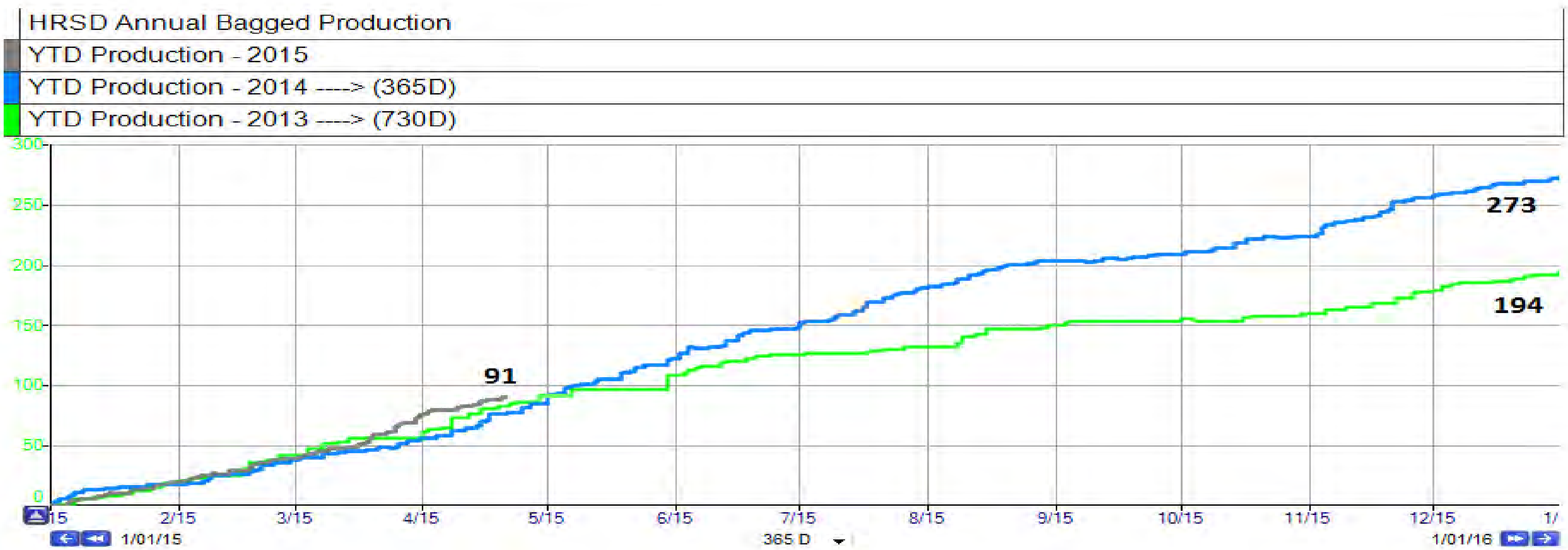
C. Bott - HRSD

COST REVIEW

	Option 1 Side Stream Treatment Cost Estimate	**Option 2 Original Ostara Cost Estimate**	Ostara CY 2013 Actual Costs	Ostara CY 2014 Projected Costs
Product Sales		165,000	65,300	111,900
Annual Operating Costs	(514,800)	(88,800)	(141,900)	(86,600)
Annual Debt Service*		(425,300)	(425,300)	(425,300)
Net Annual Operating Costs**	(559,000)	(349,100)	(501,900)	(400,000)

* Sunk costs for Side Stream option
** Side Stream Net Annual Operating Costs adjusted to 2013 $

PRODUCT PRODUCTION/SALES



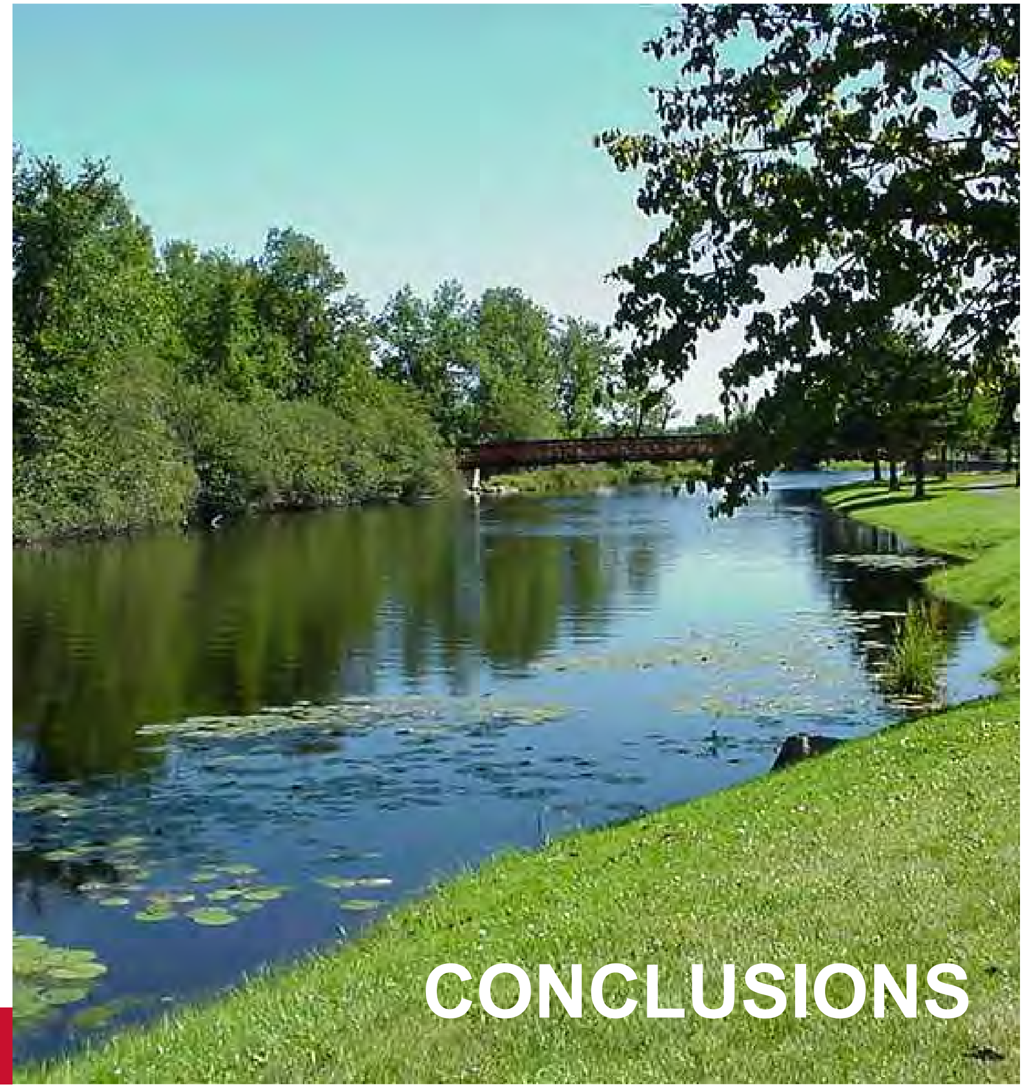
C. Bott - HRSD

HRSD AND OSTARA'S AGREEMENT

- 10-year contract with Ostara to purchase all product produced at the facility with increases to purchase price based on the CPI. KEY
- HRSD compensated for labor, materials and operating costs.
- Ostara provided the equipment and process oversight.
- HRSD retains ownership of the building and equipment after contract expires.
- Ostara markets and distributes the fertilizer product under the name as CrystalGreen™. HRSD's name is not used on any packaging.

05 CONCLUSIONS

1. Peak P may be demand side driven as efficiencies are found.
2. Does S-E wager apply to P?
3. HRSD driver = least expensive P removal technology.
4. Ostara at HRSD cost $5.6 M and costing $0.5 M/yr to operate (including debt).
5. Will sunken capital pan out compared to higher operating cost of sidestream?



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