DOE/NETL CO_2 Capture R&D Program

Michael Matuszewski

Carbon Capture Technology Manager

2014 NETL CO_2 Capture Technology Meeting

July 29th – August 1st, 2014

Thank You


RAMGEN
POWER SYSTEMS


AKERMIN


URS


GE Global Research
United States - India - China - Germany


Georgia Tech


MTR
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R&D Areas: CO_2 Capture

$12MM

Pre-Combustion

- ❑ *Solvents*
- ❑ *Sorbents*
- ❑ *Membranes*
- ❑ *Hybrid processes*
- ❑ *Water-gas shift reactor*

$80MM

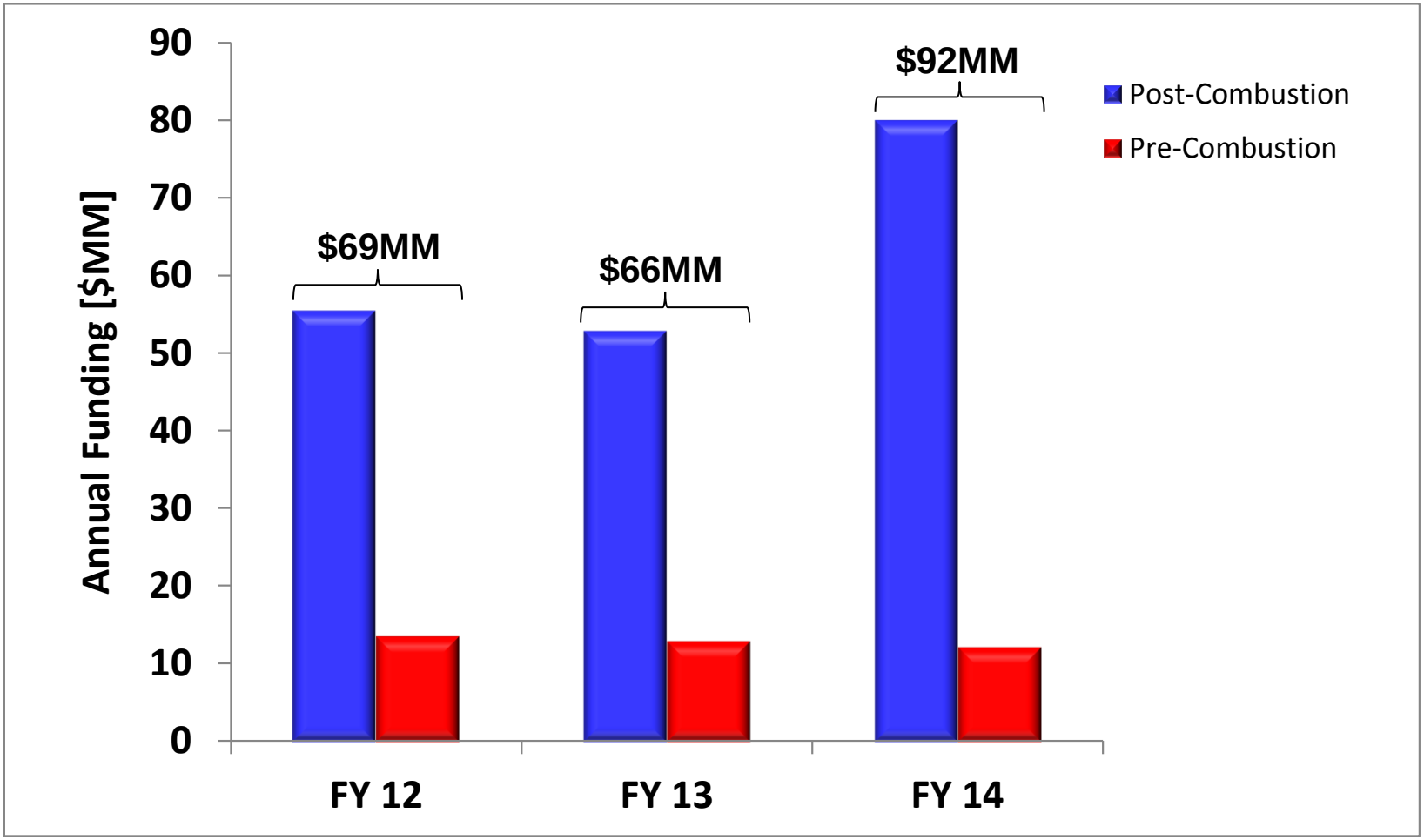
Post-Combustion

- ❑ *Solvents*
- ❑ *Sorbents*
- ❑ *Membranes*
- ❑ *Hybrid processes*

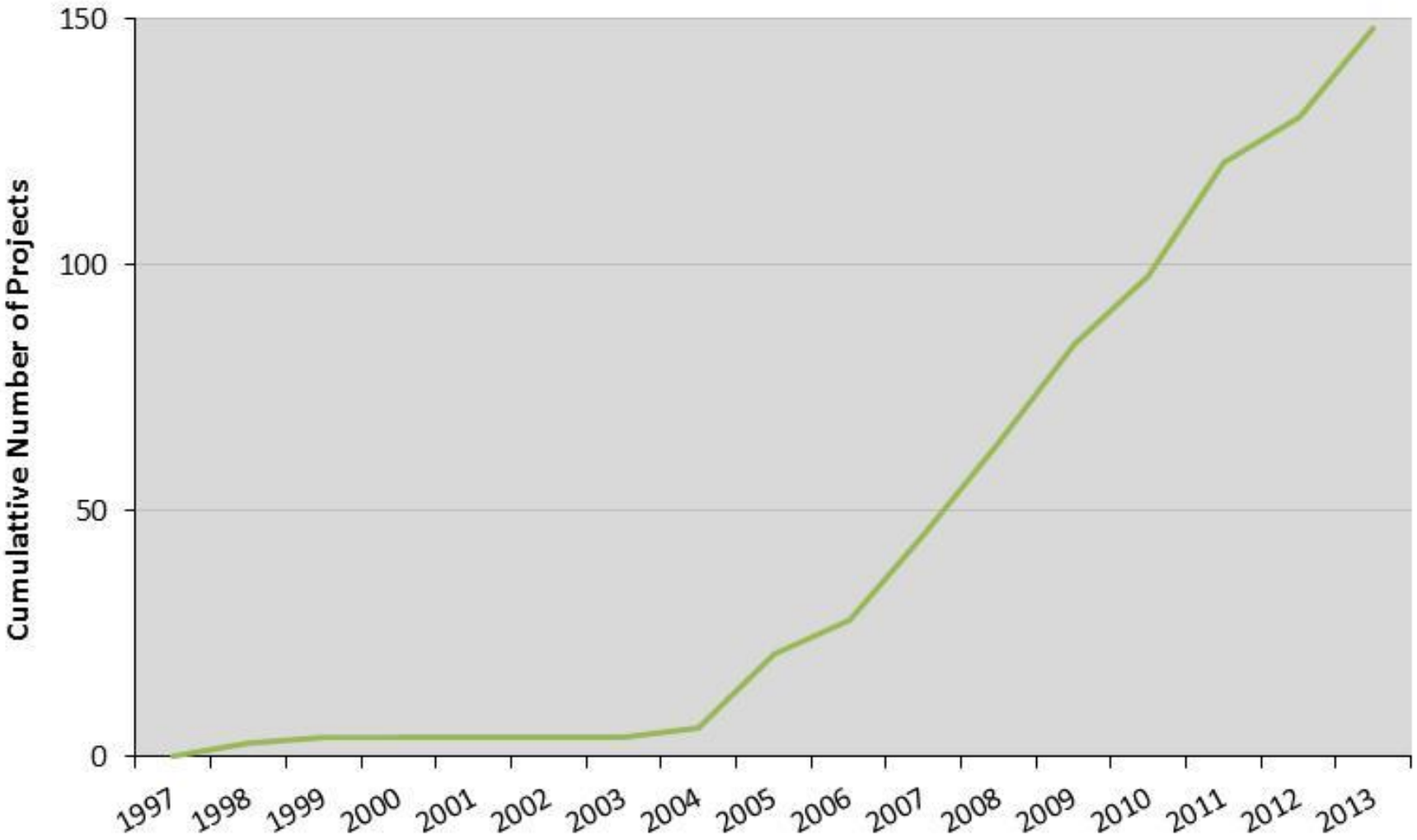
Advanced Compression

- ❑ *Intra-stage cooling*
- ❑ *Cryogenic pumping*
- ❑ *Supersonic shock wave compression*

Carbon Capture Program Budget



Growth of the NETL Carbon Capture Program



Capture Program: Active Portfolio Distribution

Program Area	Key Technology	Number of R&D Projects					Total
		TRL 1	TRL 2	TRL 3-4	TRL 5-6	TRL 7	
Post-Combustion Capture	*Solvents*		3	9	5	-	**17**
	Sorbents		3	9	2	-	**14**
	Membranes		4	5	1	-	**10**
	Hybrid/Novel		5	3	1	1	**10**
Pre-Combustion Capture	*Solvents*		2	1		-	**3**
	Sorbents		2	1	1	-	**4**
	Membranes		2	5	-	-	**7**
	Hybrid/Novel		3	-	-	-	**3**
Compression	*Compression*		-	-	2	-	**2**
TRL Totals			**24**	**33**	**12**	**1**	**70**

Need for fresh, transformational ideas
"Wave" of bench scale projects approaching graduation (1/2 of portfolio)
Up to 12 candidate ≤1MW pilots progressing toward large pilot (25-50MW)

Capture Technology Progress

Performance Improvement & Scale Up Drive Costs Down

Laboratory/Bench-Scale

- Simulated operating conditions
-Short duration tests (hours/days)
- Proof-of-concept and parametric testing
- High risk
-0.2 to 1,000 scf per minute

up to 0.5 MWe –> TRL: 2-4

Pilot-Scale Slipstream

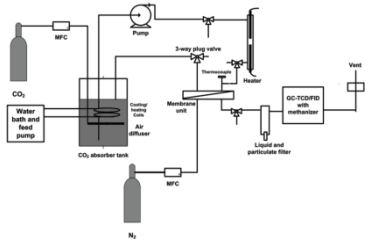
- Real operating conditions
- Longer duration tests (weeks/months)
- Lower risk
- 5,000 to 100,000 scf per minute

1.0 to 25 MWe –> TRL: 5-7

Demonstration-Scale

- Variable operating conditions
- Extended duration (typically years)
- Demonstrate integrated full-scale; Minimal risk commercial application
- CO_2 Utilization/Storage

Project(s) – 50 to 500 MWe –> TRL: 7+



1 MW Solvent Pilot (Neumann)

5 MW Oxy-combustion Pilot (Alstom)

25 MW Solvent Heat Integration (Southern Company)

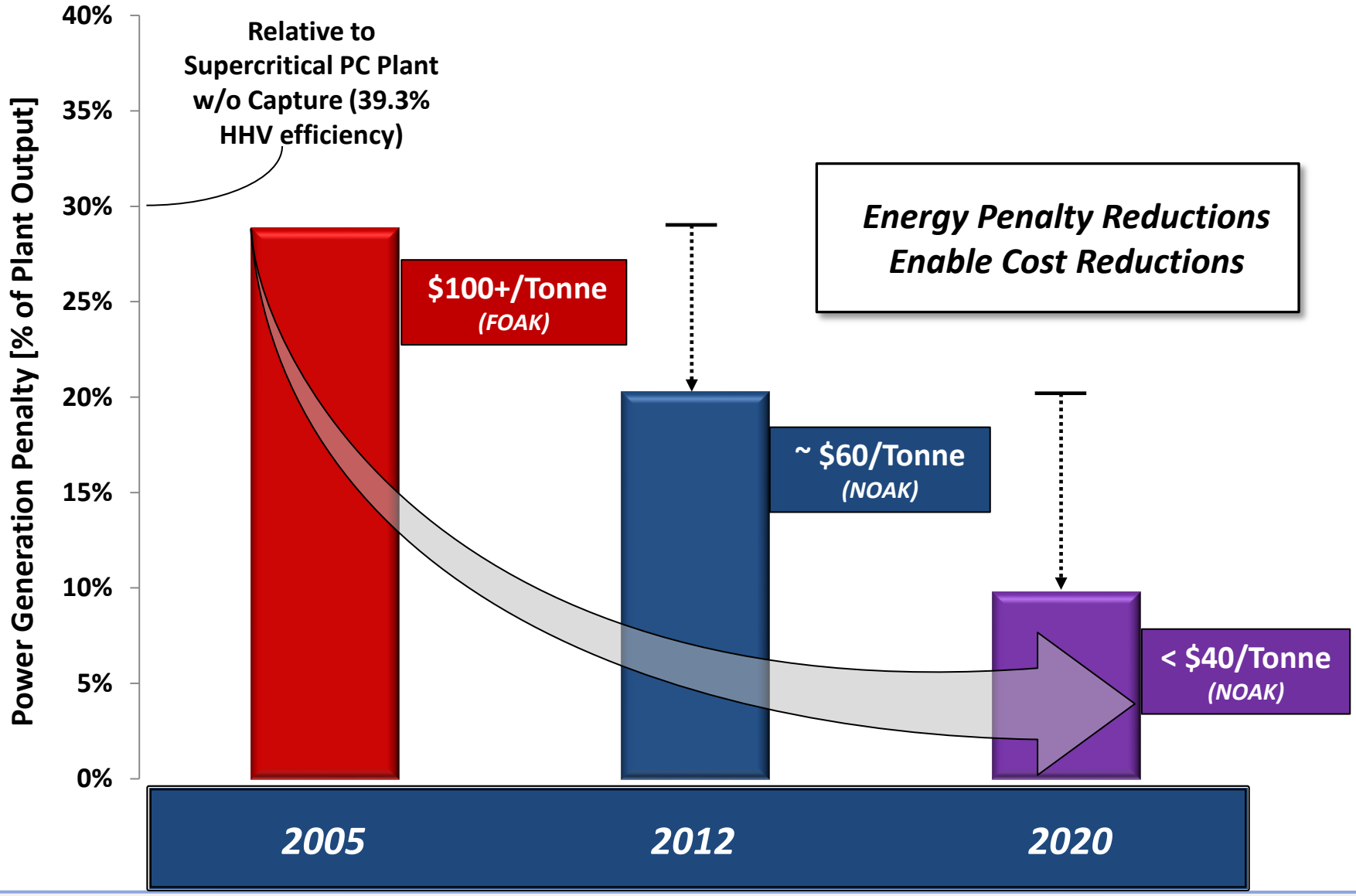
Then		*Now*		*Future*
(>$100/Tonne)	→	*(~$60/Tonne)*	→	*(<$40/Tonne)*

U.S. CO_2 Capture

Pilots/Demos through 2017

Performance Improvements in Capture R&D

Improvements Drive Down CO_2 Captured Cost



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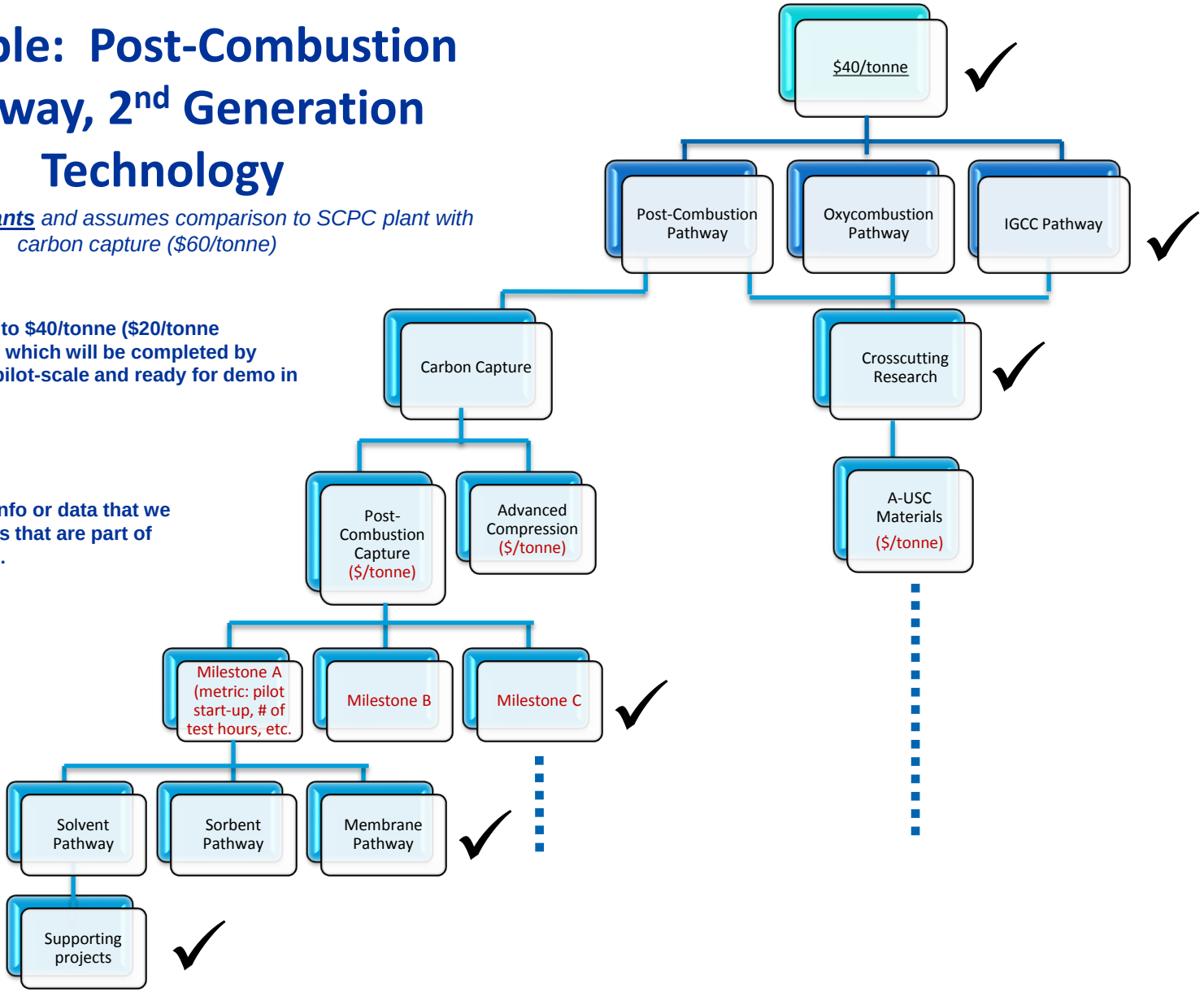
Tracking DOE Goals

Example: Post-Combustion Pathway, 2nd Generation Technology

*This is for **New Plants** and assumes comparison to SCPC plant with carbon capture ($60/tonne)*

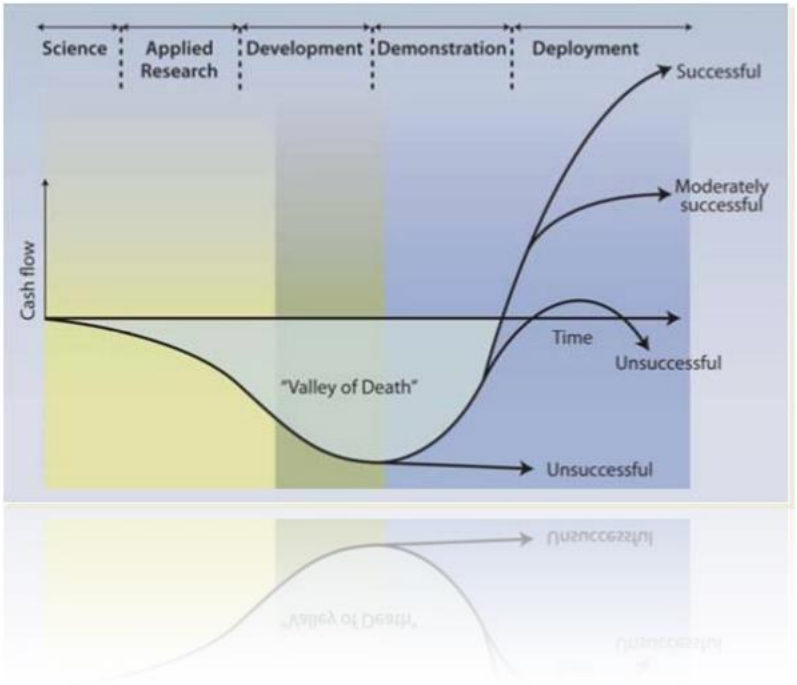
Overall Goal: $60/tonne to $40/tonne ($20/tonne reduction) through R&D which will be completed by 2020 (i.e, through large-pilot-scale and ready for demo in 2020-2025 timeframe)

Check marks indicate info or data that we have available, or boxes that are part of the chart's flow pattern.



Capture Program Focus Areas

- **Conduct Large Scale Pilots – 5-50MWe**
  - Bridge the "*Valley of Death*"
- **Sustain Encouragement of Transformational Research**
  - Ensure continual progress
  - FWPs, ARPA-E Collaborations
- **Intelligent Research Guidance**
  - High throughput analysis & optimization
  - CCSI Collaboration
- **Increase Cost Efficiencies**
  - Capital is major contributor to advanced system costs
  - Engaging EERE AMO
  - "Learning by doing" – e.g. pilots



*Valley of Death graphic credited to: http://www.energy.ca.gov/research/buildings/demonstrations.html

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2014 Capture SBIR

4 New Key Technology Areas

~70% Increase in Interest

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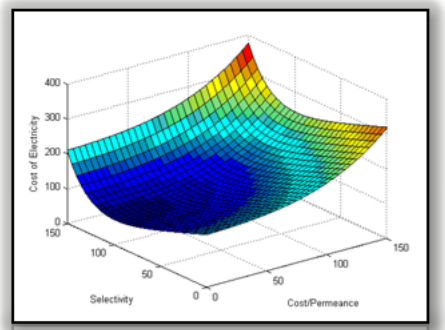
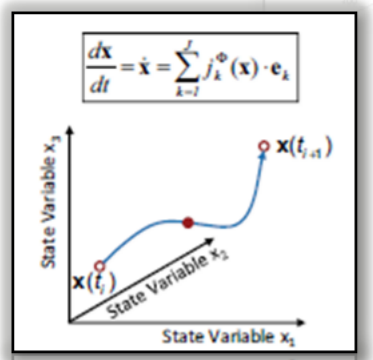
$$\min f(x,y)$$
$$\text{subject to:}$$
$$g(x,y)=0$$
$$h(x,y)\le 0$$
$$x\in R^n, y\in\{0,1\}^m$$





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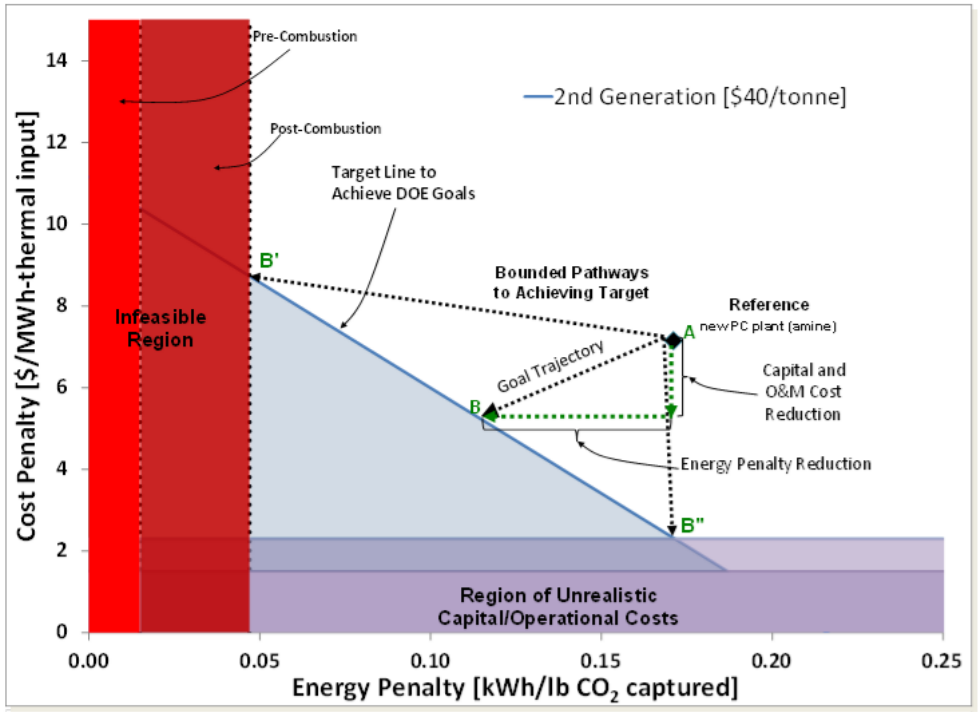

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Recent Accomplishments

2013 FOA Results

Title: *"Development of Post-Combustion and Pre-Combustion Carbon Dioxide Capture Technologies for New and Existing Power Plants"*

- Fill in the R&D technology gaps identified since the last FOA
  - Hybrid Approaches (3 bench-scale projects selected)
  - Enabling Technologies (2 projects selected)
- Continuation of ARPA-E projects
  - 4 projects selected – funding for these projects could not have been extended under ARPA-E
- Continuation of "best-in-class" FE R&D projects in the existing Capture Program and through the SBIR program
  - 2 bench-scale projects selected
- Scale-up of the most promising laboratory/bench-scale projects to pilot-scale (0.5 to 5 MWe)
  - 8 existing bench-scale projects were advanced to pilot-scale. . .highest priority of the FOA
- **A total of 18 projects were awarded**

National Carbon Capture Center Awarded

Pilot Solvent Test Unit

- 5 year $150MM
- $100MM Capture Funding
- Independent Test Facility
- Supports Capture & Gasification

TRIG Gasifier

Post Combustion

- ❑ PC4 Facility – 4.3MWe
- ❑ Real PC flue gas
- ❑ Bench through pilot scale
- ❑ ~25,000 hours of testing
- ❑ 15 Technologies tested
- ❑ "Tech-Flexible"

Pre Combustion

- ❑ 6.3MWe Trig gasifier
- ❑ Air- or O_2 fired syngas
- ❑ Bench through pilot scale
- ❑ ~20,000 hours of testing
- ❑ 13 gasifier runs
- ❑ "Tech-Flexible"

U.S. DEPARTMENT OF ENERGY · NETL · SOUTHERN COMPANY · EPRI ELECTRIC POWER RESEARCH INSTITUTE · nrg · ArchCoal · AEP AMERICAN ELECTRIC POWER · DUKE ENERGY · CLOUD PEAK ENERGY · Luminant

– World Class Carbon Capture Technology Test Facility –

NETL

2013 SBIR

Encouraging Transformational Research

- **<u>Expanding borders</u> of capture technology**

- **Broadened Horizons to New Approaches**
  - Electrochemical
  - Advanced/Non-Aqueous Solvents
  - Direct CO_2 Phase Change
  - Nano-Engineered Materials for CO_2 Capture
  - Process Intensification

- **Hybrid systems – working together!**

"If I have seen further than others, it is by standing upon the shoulders of giants." – **Isaac Newton**

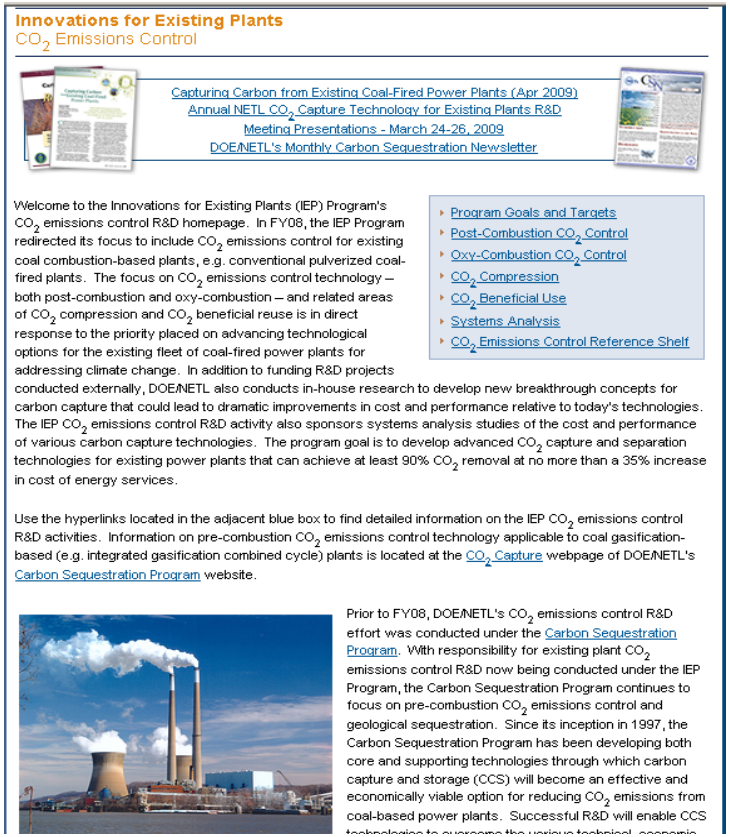
For More Information About the NETL Carbon Capture Program

- **NETL Website:**
  - www.netl.doe.gov
- **Capture Program Website:**
  - www.netl.doe.gov/technologies/coalpower/ewr/co2/index.html

Reference Shelf

- **Annual CO_2 Capture Meeting**

- **Office of Fossil Energy website:**
  - www.fe.doe.gov



Michael S. Matuszewski
Technology Manager
Carbon Capture Program
National Energy Technology Laboratory
U. S. Department of Energy
(Tel) 412-386-5830
michael.matuszewski@netl.doe.gov