

U.S. Department of Energy Advanced Energy Systems Overview

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Office of Fossil Energy



U.S. DEPARTMENT OF
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DOE/FE's top Clean Coal and CCS priorities

Success of the demos

- Serial # 1 in operation 2013-2018
- A deep and rich set of public learning

Reimagining the coal and CCS RD&D portfolio

- Advanced combustion
- Capture and storage: incl. footprint reduction
- 2nd generation large pilots

International Partnerships

- Asia, Europe and other key countries

New mode: delivering solutions



U.S. DEPARTMENT OF
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Office of Fossil Technology Systems: Program Summary

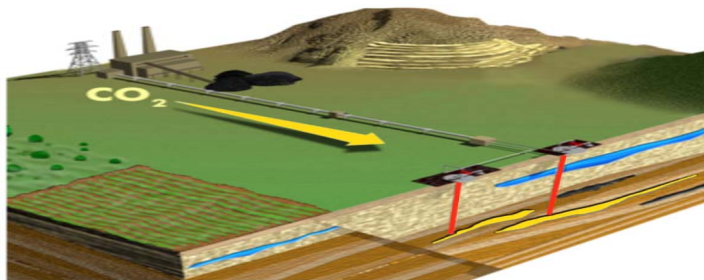


CO₂ Capture and Compression

Cost effective capture for new and existing plants

Major Goals:

- 2016: complete 2nd gen field tests (~1.0 MW scale)
- 2020: complete 2nd gen pilot tests (10 to 25 MW)
- 2025: complete transformational tech. field tests (~ 1.0 MW)



CO₂ Storage

Safe, permanent storage of CO₂ from power and industry

Major Goals:

- 2020: Technologies and tools available to measure and account for 99% of injected CO₂
- 2020: CCS best practices and protocols completed based upon RCSP Phase III activities



Advanced Energy Systems

Gasification, Adv Turbines, Adv Combustion, CBTL, and fuel cells

Major Goals:

- 2016: Complete Warm Gas Cleanup demo.
- 2025: 20-30% Reduction in Combined Cycle Capital Cost (2nd gen)
- 2025: Advanced combustion ready for pilot scale operation



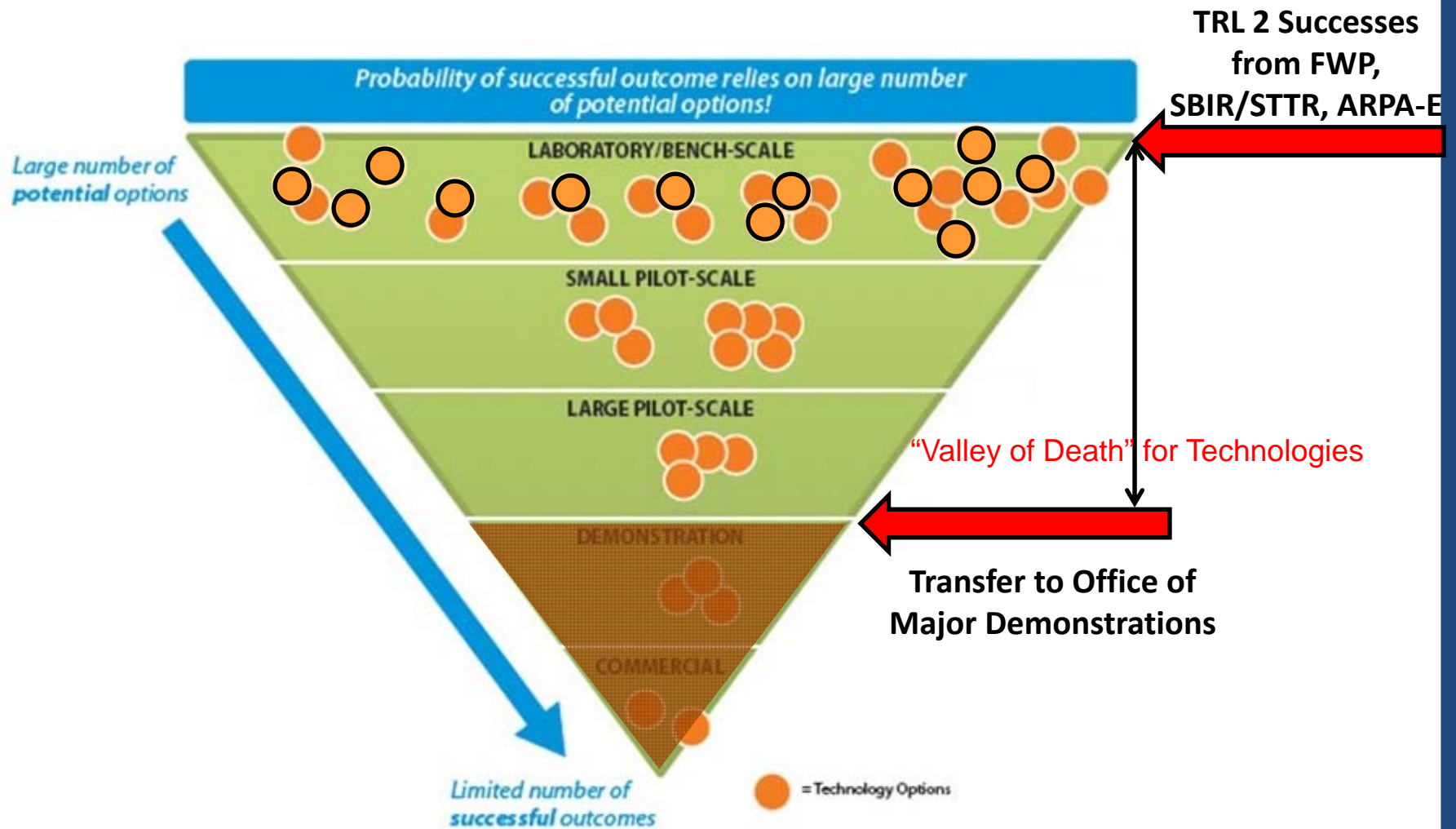
Cross-Cutting Research

Crosscutting technology development program

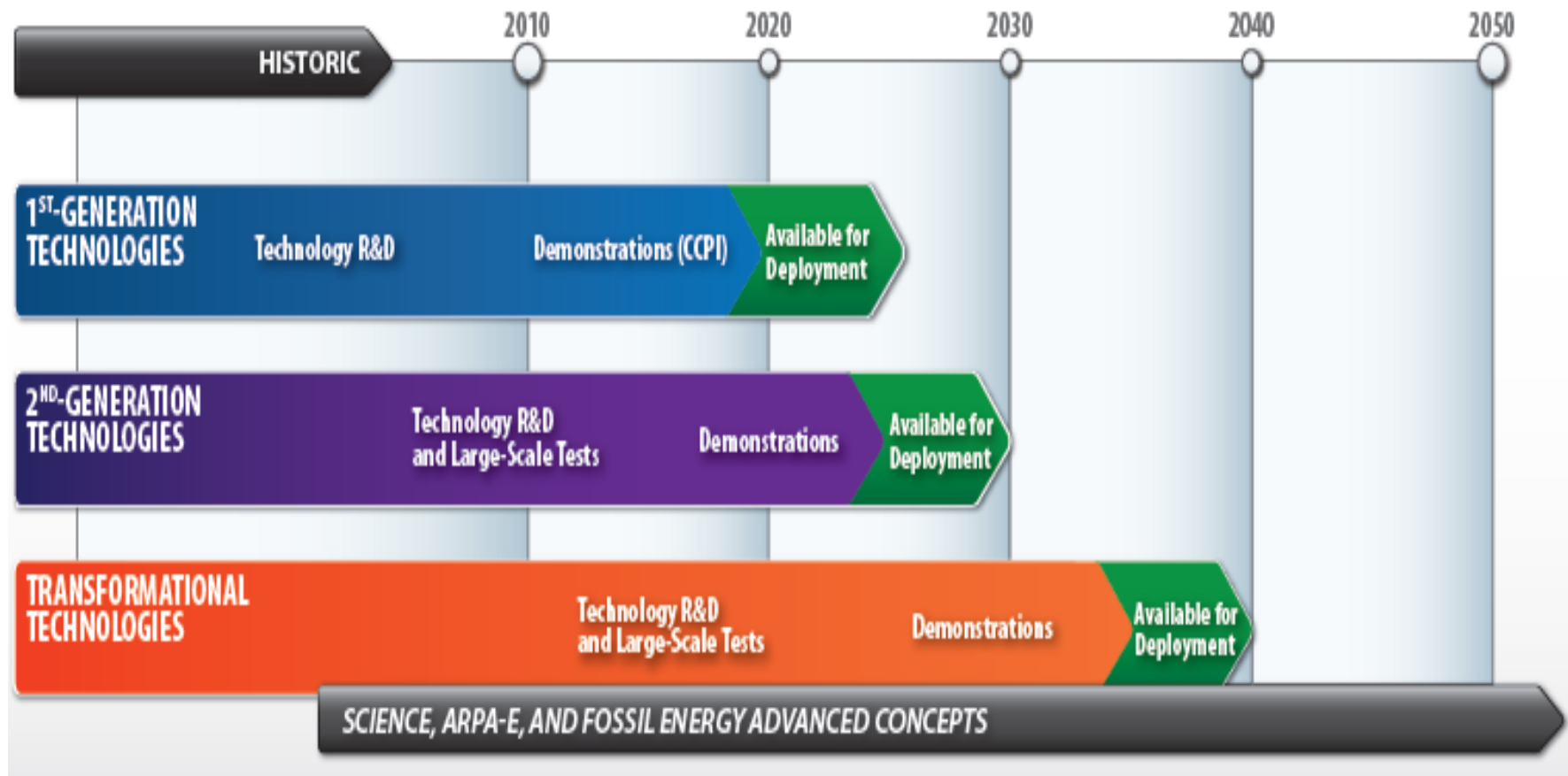
Major Goals:

- 2016: Advance 2nd gen materials, sensors, modeling technologies to applied programs
- 2020: Develop distributed communication sensor networks (transformational tech.)

Pathway for Technology Commercialization



A technology pipeline for affordable CCS



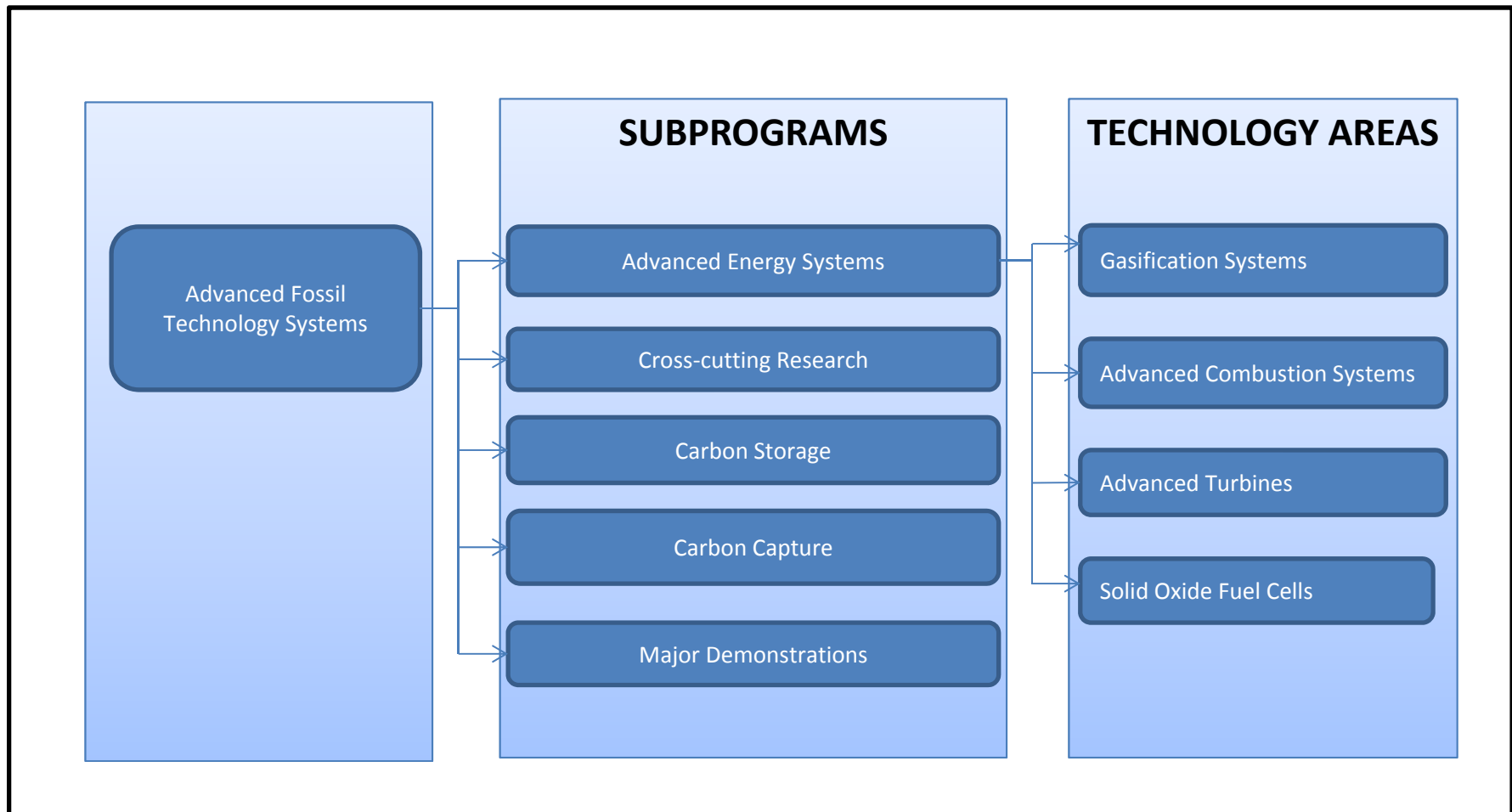
We need more 2nd generation pilots!



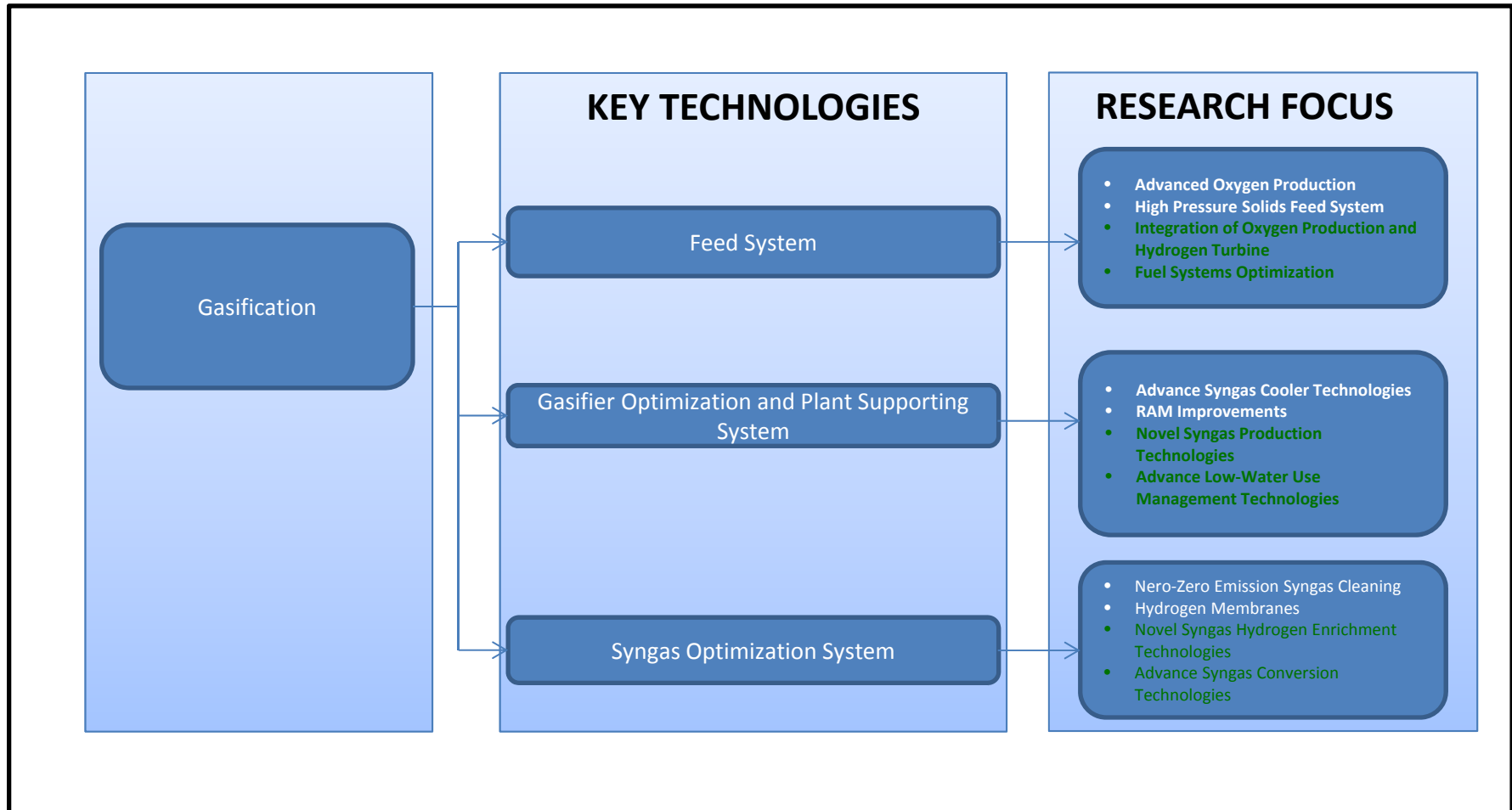
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ENERGY

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Advanced Fossil Technology Systems



Advanced Fossil Technology Systems



Gasification Systems Program

Key Technologies

Feed Systems

- Oxygen separation
- Expand fuel flexibility
- Increase efficiency and reliability, and improve economics

Gasifier Optimization and Plant Supporting Systems

- Improve reliability
- Increase efficiency and reliability, and improve economics

Syngas Supporting Systems

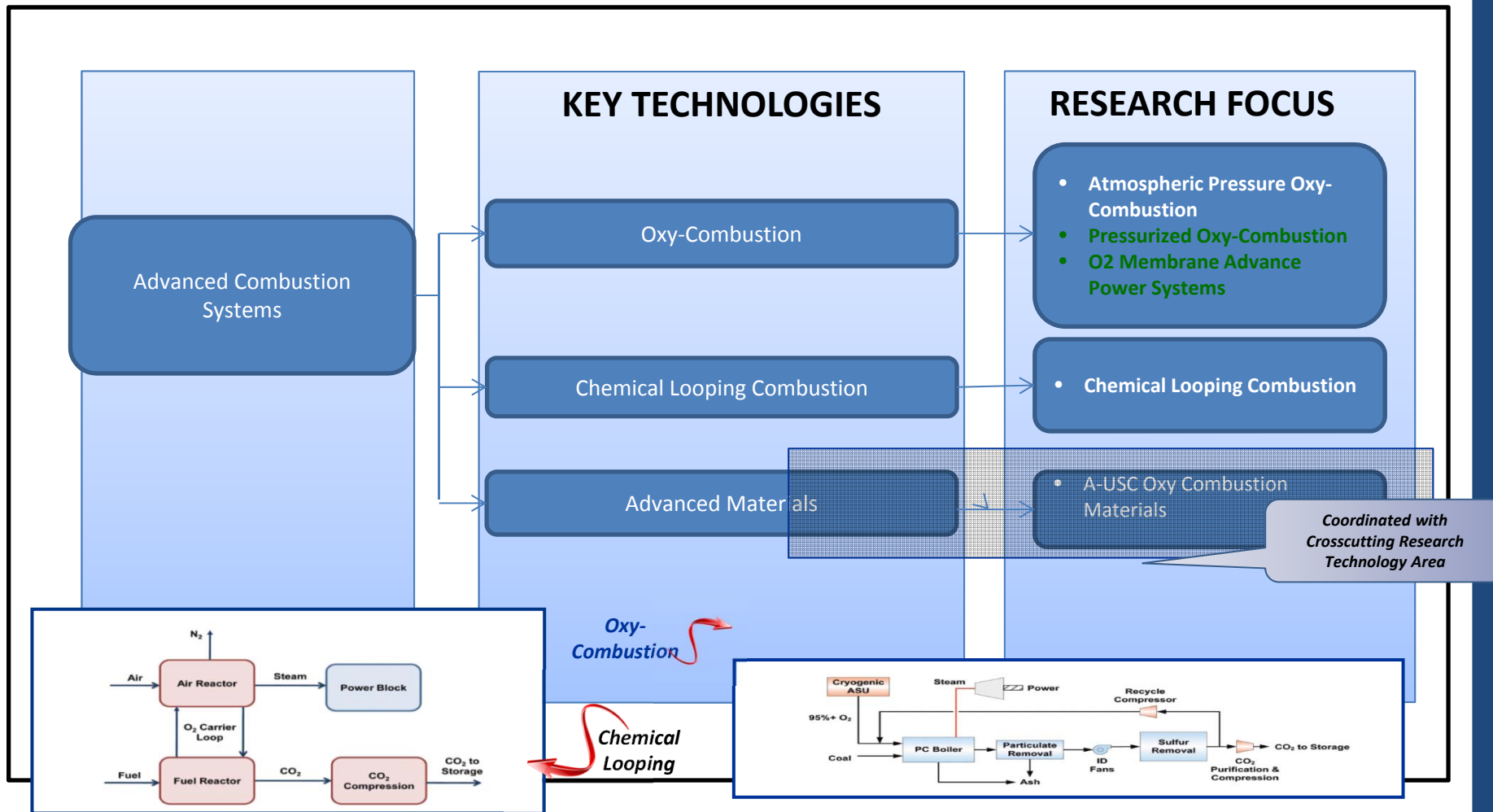
- Hydrogen and carbon dioxide separation
- Control multi-contaminants to extremely low levels
- Increase efficiency and reliability, and improve economics



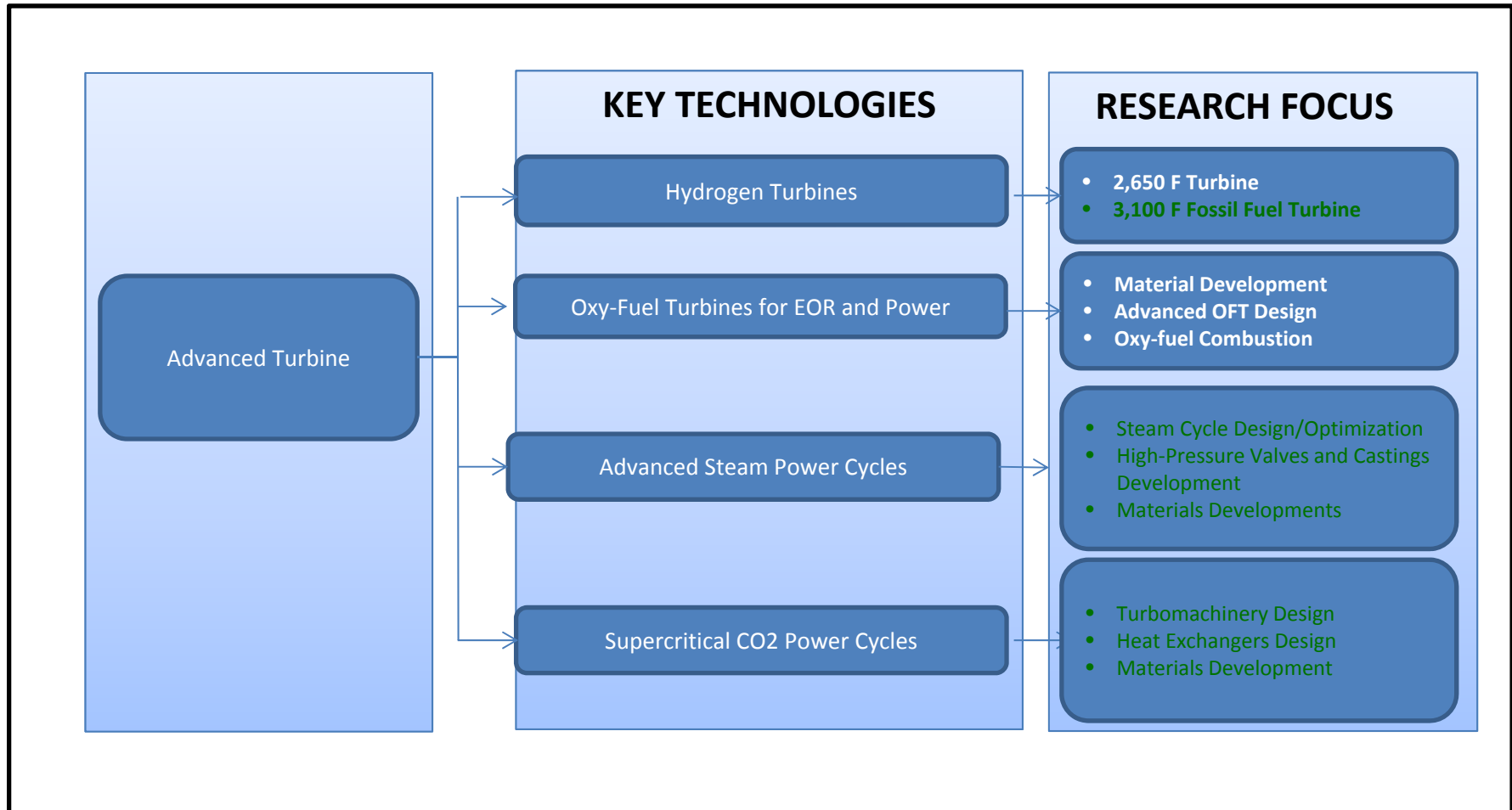
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Advanced Fossil Technology Systems



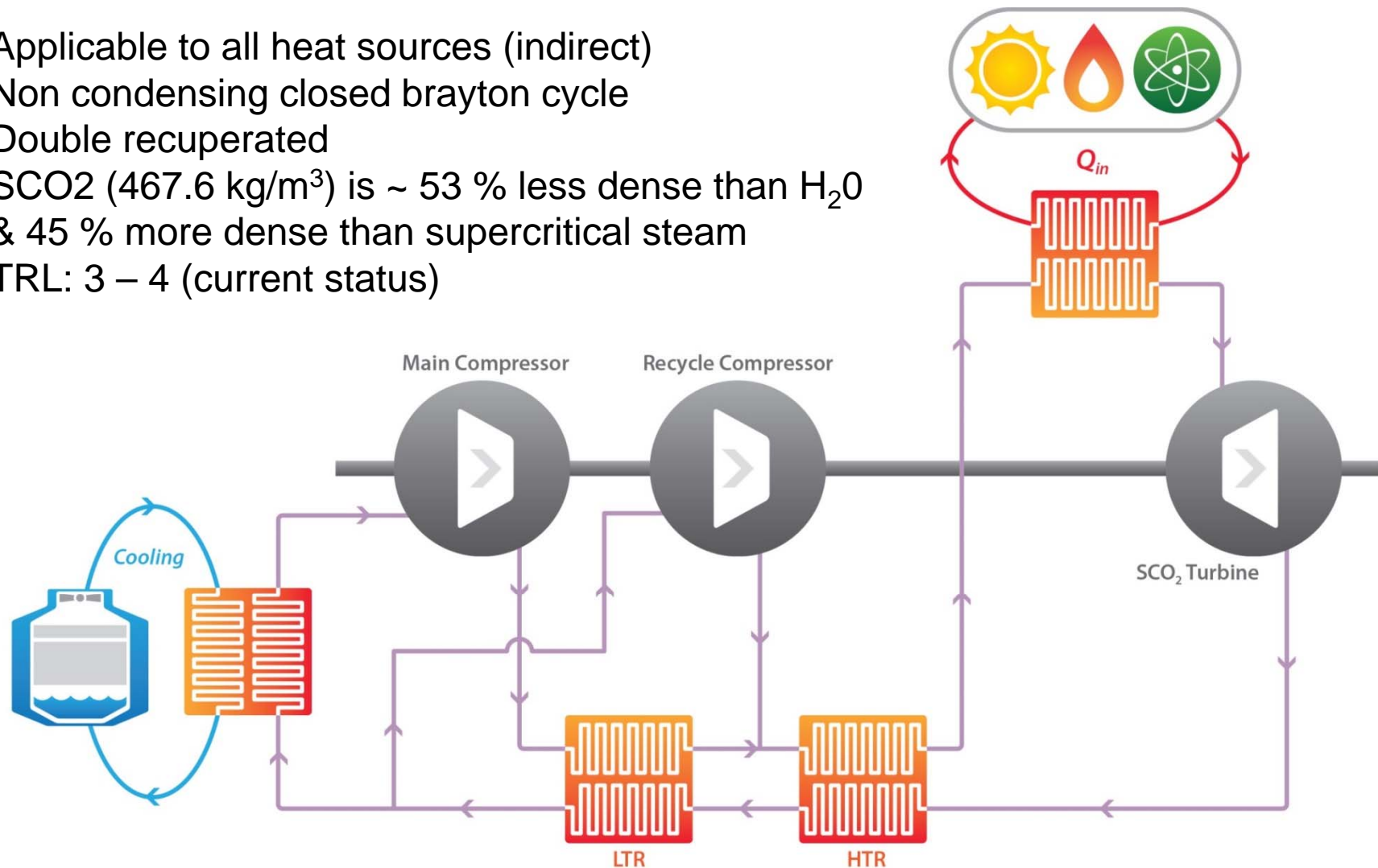
Advanced Fossil Technology Systems



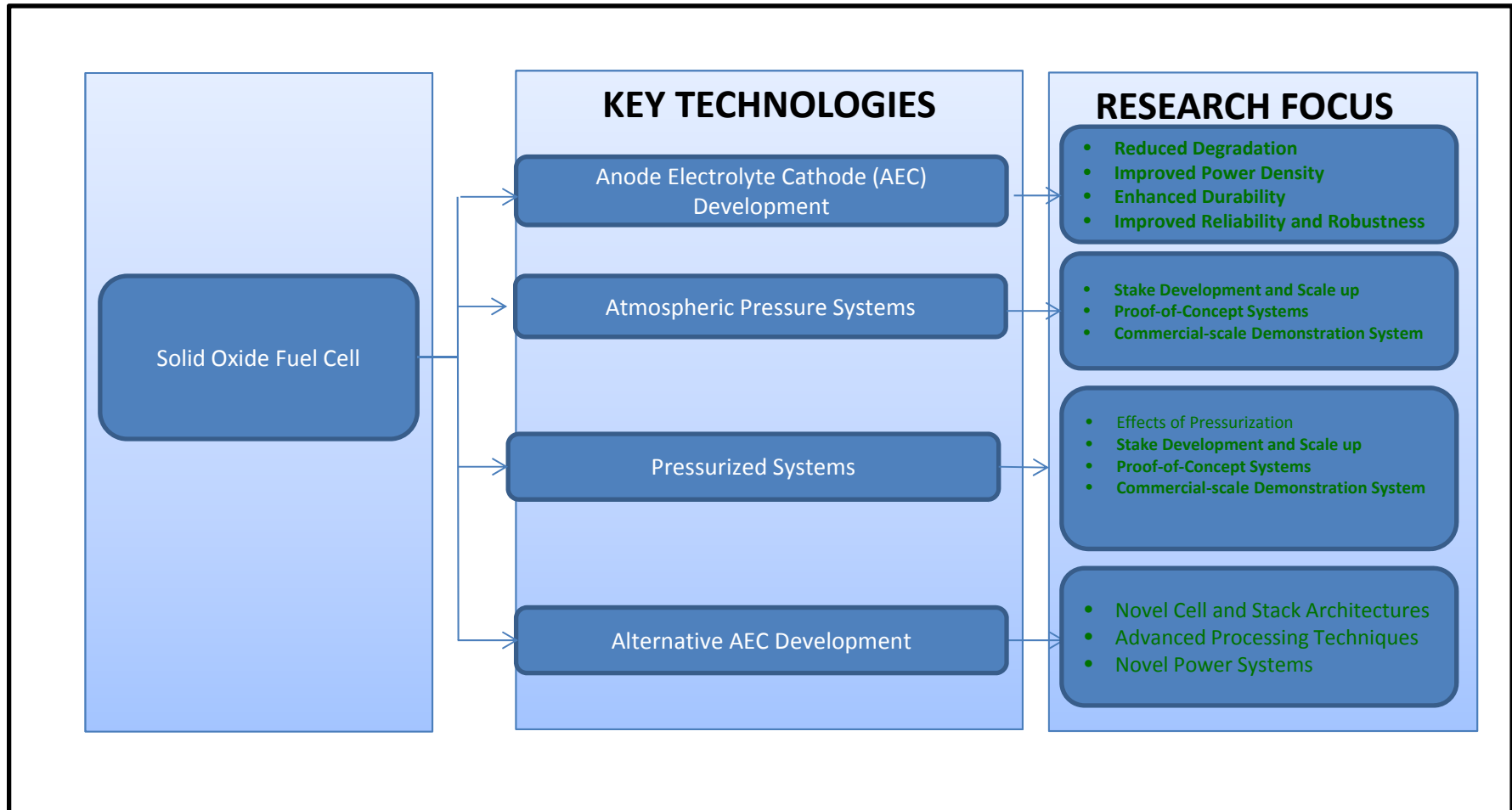
SCO₂ Power Cycle Overview

Recompression Brayton Cycle

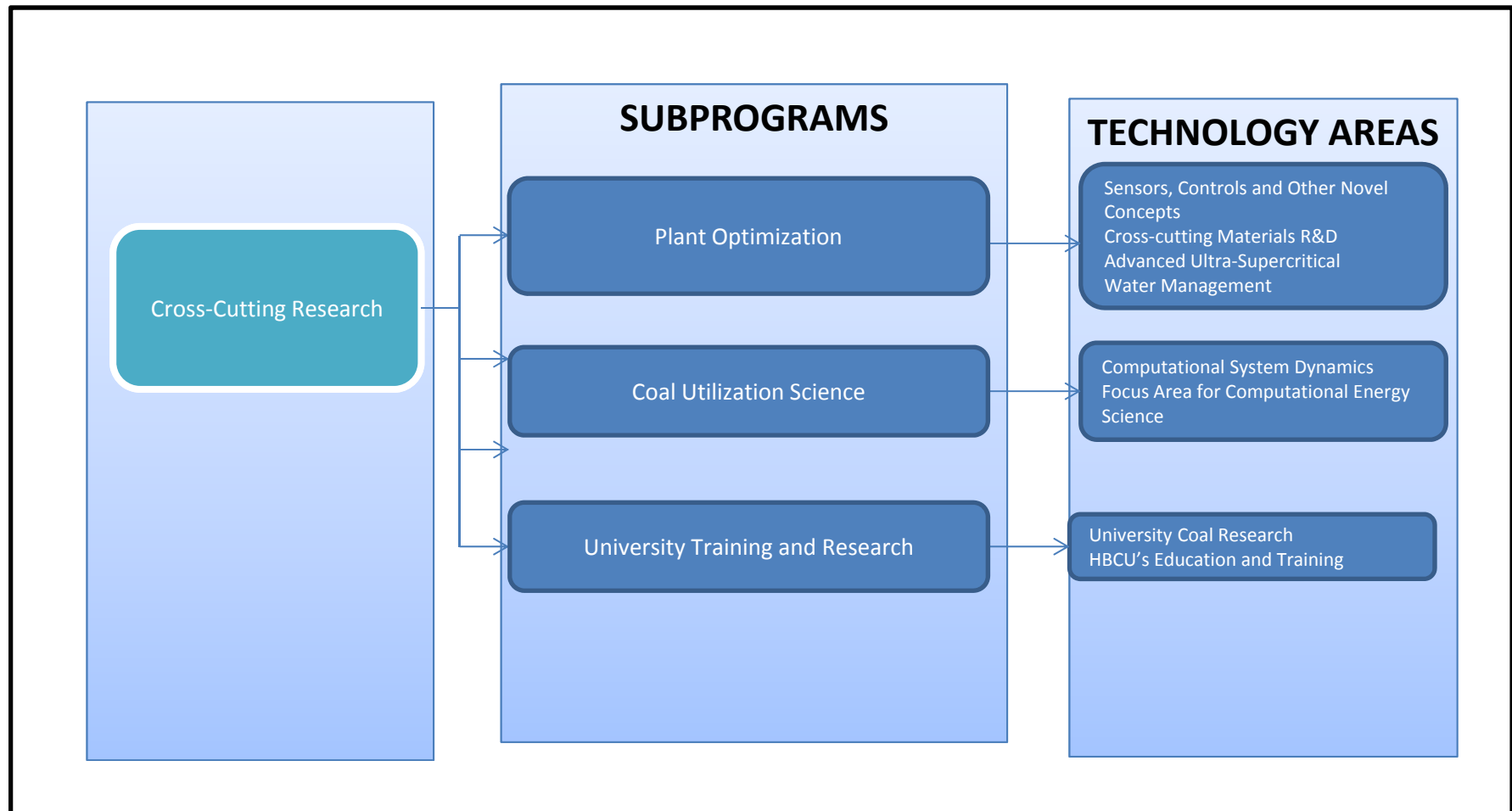
- Applicable to all heat sources (indirect)
- Non condensing closed brayton cycle
- Double recuperated
- SCO₂ (467.6 kg/m³) is ~ 53 % less dense than H₂O & 45 % more dense than supercritical steam
- TRL: 3 – 4 (current status)



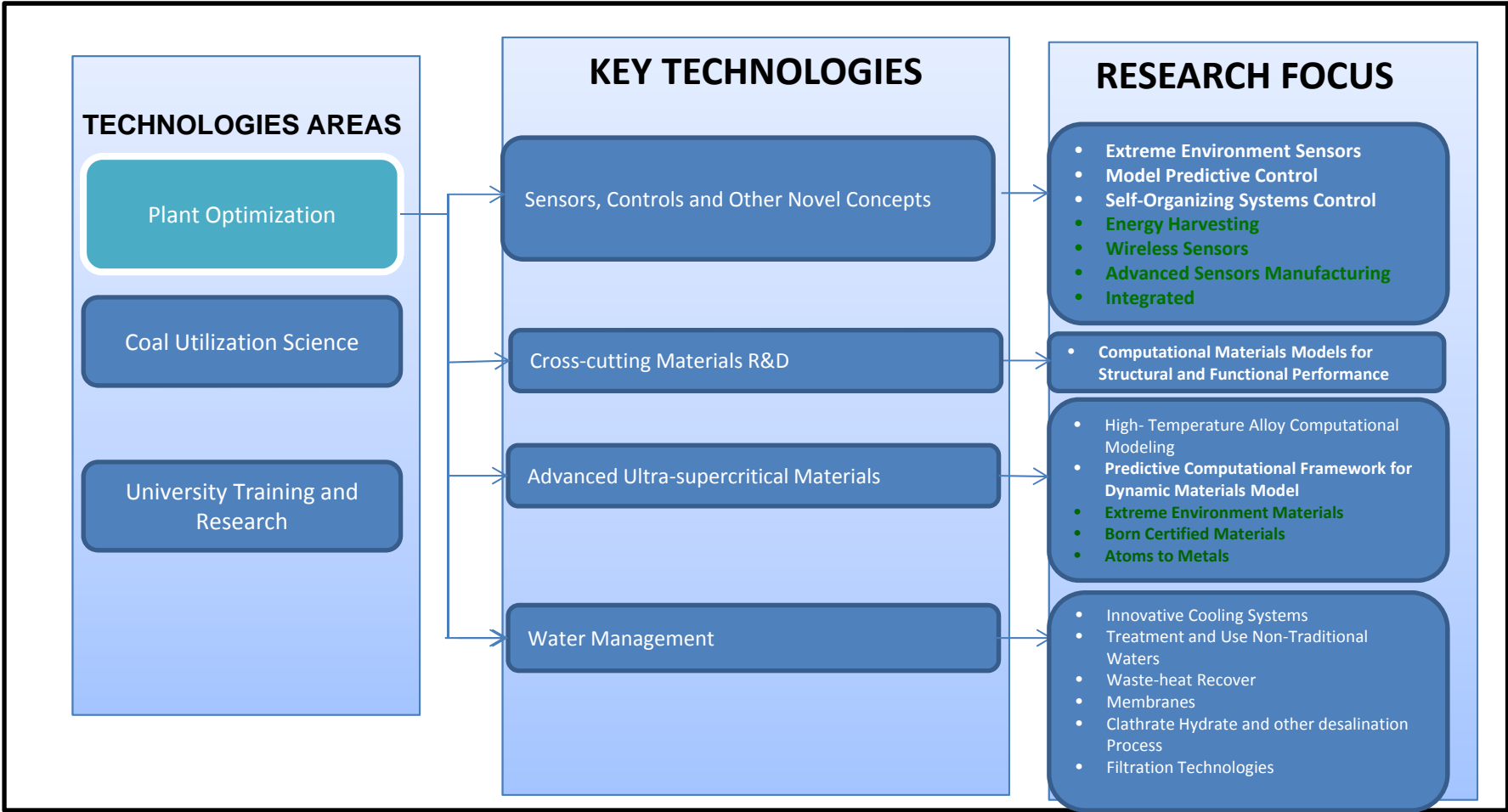
Advanced Fossil Technology Systems



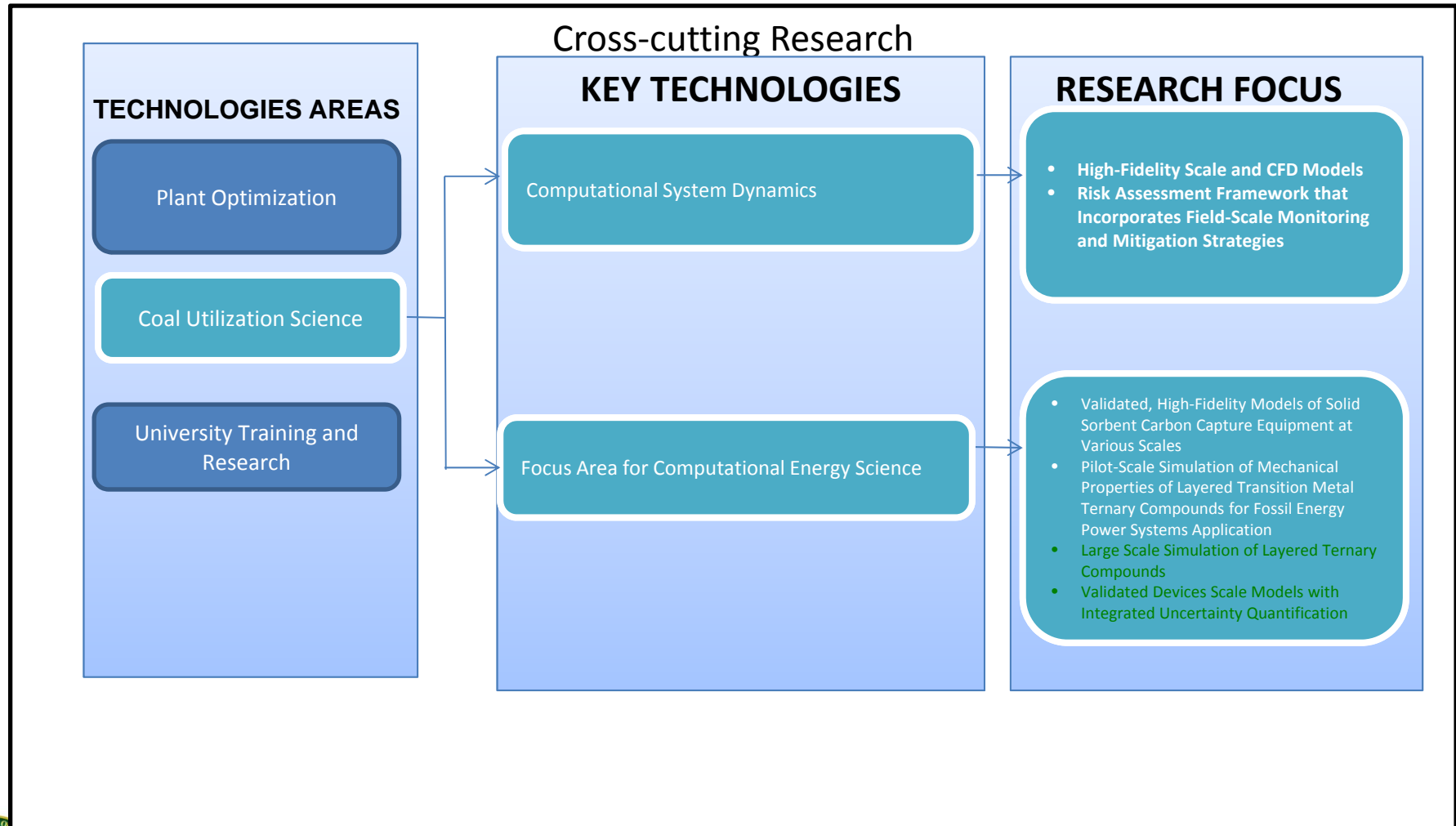
Advanced Fossil Technology Systems

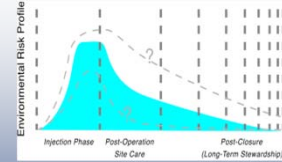
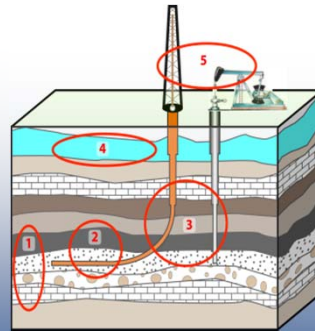
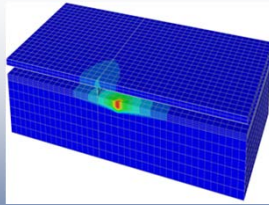
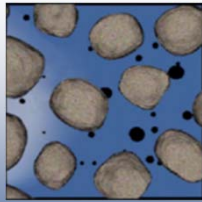


Advanced Fossil Technology Systems



Advanced Fossil Technology Systems Clean Coal and Carbon Management





National Risk Assessment Partnership

Leveraging DOE's competency in science-based prediction for engineered-natural systems to build confidence in the business case for CO₂ storage.

Building toolsets and the calibration & validation data to quantify ...

- Potential impacts related to release of CO₂ or brine from the storage reservoir
- Potential geomechanical impacts due to injection of CO₂

Technical Team



U.S. DEPARTMENT OF ENERGY

Fossil Energy

Stakeholder Group



Blue Source

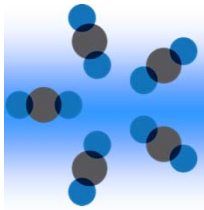


Texas Railroad Commission



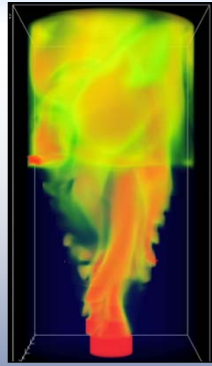
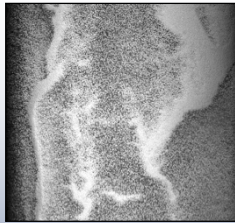
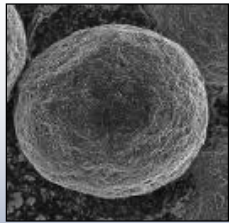
Wade, LLC

Because change happens.™



CCSI For Accelerating Technology Development

Carbon Capture Simulation Initiative



Identify promising concepts



Reduce the time for design & troubleshooting



Quantify the technical risk, to enable reaching larger scales, earlier



Stabilize the cost during commercial deployment

National Labs



Academia



Industry



U.S. DEPARTMENT OF ENERGY

Fossil Energy

FE Water Management Program

Program Goals:

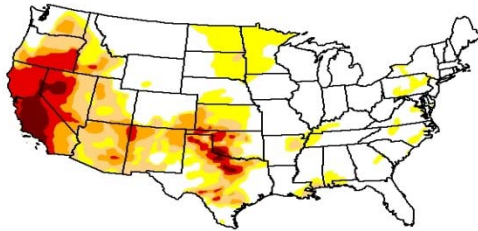
- Reduce freshwater withdrawals by >30% by 2030 for Fossil Energy based power generation
- Maintain water consumption within Fossil Energy based power generation to 2010 levels
- Develop and deploy low cost water treatment technologies to enable zero discharge systems

Program Elements:

- Increase process efficiency and intensification of Fossil Energy based thermoelectric power generation,
- Accelerate development and deployment of Fossil Energy based power generation with low water footprint,
- Improve heat transfer and utilization,
- Develop treatment and use of water within Fossil Energy power generation and related infrastructures, and
- Support information generation, integration, and planning.



**U.S. Drought Monitor
CONUS**



January 6, 2015
(Released Thursday, Jan. 8, 2015)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	55.85	44.15	28.10	16.76	8.84	2.48
Last Week 12/29/2014	53.20	46.80	28.68	16.93	8.96	2.54
3 Months Ago 10/05/2014	53.03	46.97	30.51	18.66	9.46	3.87
Start of Calendar Year 12/01/2014	53.20	46.80	28.68	16.93	8.96	2.54
Start of Water Year 9/01/2014	52.22	47.78	30.57	18.66	9.41	3.85
One Year Ago 1/06/2014	46.64	53.36	33.22	17.12	4.13	0.37

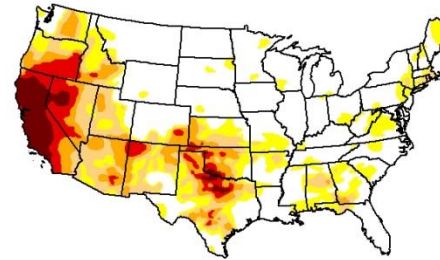
Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Brad Rippey
U.S. Department of Agriculture

USDA <http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



October 7, 2014
(Released Thursday, Oct. 9, 2014)
Valid 8 a.m. EDT

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	53.03	46.97	30.51	18.66	9.46	3.87
Last Week 9/30/2014	52.22	47.78	30.57	18.66	9.41	3.85
3 Months Ago 7/06/2014	54.53	45.47	34.25	24.95	12.02	2.94
Start of Calendar Year 12/01/2013	48.24	51.76	30.95	16.67	3.96	0.37
Start of Water Year 9/01/2013	52.22	47.78	30.57	18.66	9.41	3.85
One Year Ago 10/07/2013	42.23	57.77	38.59	19.80	2.91	0.29

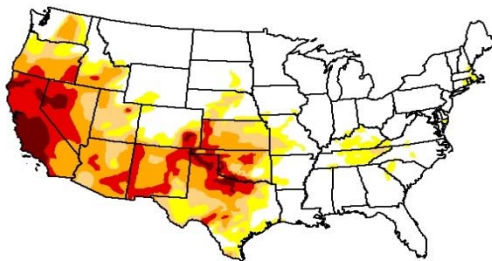
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■ D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Mark Svoboda
National Drought Mitigation Center

USDA <http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



July 1, 2014
(Released Thursday, Jul. 3, 2014)
Valid 8 a.m. EDT

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	55.57	44.43	34.01	25.00	11.98	2.98
Last Week 6/24/2014	54.67	45.33	35.03	24.82	11.23	2.91
3 Months Ago 4/01/2014	47.12	52.88	38.37	24.12	9.80	2.18
Start of Calendar Year 12/01/2013	48.24	51.76	30.95	16.67	3.96	0.37
Start of Water Year 10/01/2013	39.57	60.43	41.21	20.70	3.06	0.29
One Year Ago 7/02/2013	49.11	50.89	44.06	32.95	13.57	4.68

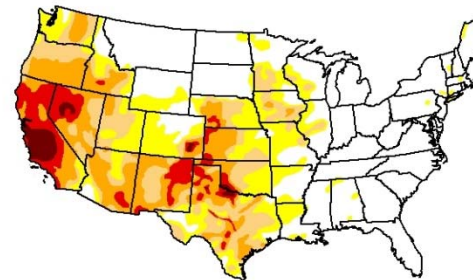
Intensity:
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■ D2 Severe Drought

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Author(s):
Anthony Artusa
NOAA/NWS/NCEP/CPD

USDA <http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



March 4, 2014
(Released Thursday, Mar. 6, 2014)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	46.53	53.47	35.85	21.56	7.40	1.57
Last Week 2/25/2014	45.89	54.11	36.08	21.54	7.65	1.76
3 Months Ago 12/05/2013	44.55	55.45	30.59	16.50	3.82	0.39
Start of Calendar Year 12/01/2013	48.24	51.76	30.95	16.67	3.96	0.37
Start of Water Year 10/01/2013	39.57	60.43	41.21	20.70	3.06	0.29
One Year Ago 3/04/2013	34.33	65.67	53.34	36.44	17.04	5.45

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

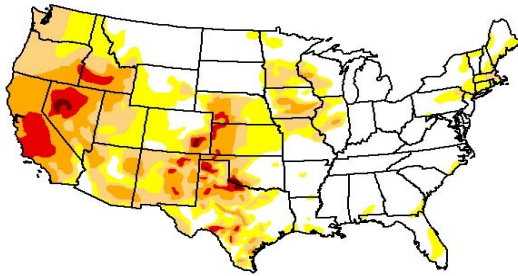
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Brad Rippey
U.S. Department of Agriculture

USDA <http://droughtmonitor.unl.edu/>



**U.S. Drought Monitor
CONUS**



January 7, 2014
(Released Thursday, Jan. 9, 2014)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	46.64	53.36	33.22	17.12	4.13	0.37
Last Week 12/31/2013	48.24	51.76	30.95	16.67	3.96	0.37
3 Months Ago 10/6/2013	42.23	57.77	38.59	19.60	2.91	0.29
Start of Calendar Year 12/21/2013	48.24	51.76	30.95	16.67	3.96	0.37
Start of Water Year 6/25/2013	39.57	60.43	41.21	20.70	3.06	0.29
One Year Ago 1/6/2013	28.26	71.74	60.26	41.71	20.80	6.70

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Mark Svoboda
National Drought Mitigation Center



June 4, 2013
(Released Thursday, Jun. 6, 2013)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	45.02	54.98	44.11	28.49	11.44	4.79
Last Week 5/28/2013	43.13	56.87	44.34	29.56	11.75	4.74
3 Months Ago 3/5/2013	34.33	65.67	53.34	36.44	17.04	5.45
Start of Calendar Year 1/6/2013	27.22	72.78	61.09	42.05	21.31	6.75
Start of Water Year 6/25/2012	23.41	76.59	65.45	42.12	21.48	6.12
One Year Ago 6/5/2012	36.01	63.99	38.60	19.92	4.60	0.60

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
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■ D2 Severe Drought

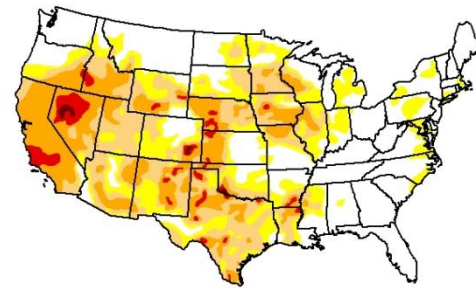
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
David Simera
Western Regional Climate Center



<http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



October 1, 2013
(Released Thursday, Oct. 3, 2013)
Valid 7 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	39.57	60.43	41.21	20.70	3.06	0.29
Last Week 9/24/2013	38.06	61.94	45.46	25.33	4.33	0.31
3 Months Ago 7/2/2013	49.11	60.89	44.06	32.95	13.57	4.68
Start of Calendar Year 1/5/2013	27.22	72.78	61.09	42.05	21.31	6.75
Start of Water Year 10/1/2012	39.57	60.43	41.21	20.70	3.06	0.29
One Year Ago 10/2/2012	24.10	75.90	64.58	40.07	20.12	6.07

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

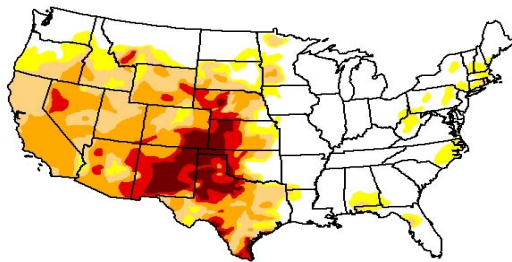
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
David Miskus
NOAA/NWS/NCEP/CPC



<http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



March 5, 2013
(Released Thursday, Mar. 7, 2013)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	34.33	65.67	53.34	36.44	17.04	5.45
Last Week 2/26/2013	33.62	66.38	54.17	36.35	16.95	5.45
3 Months Ago 1/4/2013	23.84	76.16	62.37	42.22	20.63	6.49
Start of Calendar Year 1/6/2013	27.22	72.78	61.09	42.05	21.31	6.75
Start of Water Year 6/25/2012	23.41	76.59	65.45	42.12	21.48	6.12
One Year Ago 3/6/2012	42.81	57.19	39.02	19.30	7.24	2.44

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

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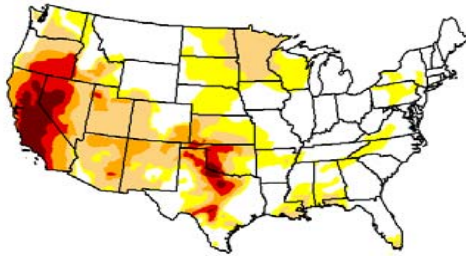
Author(s):
Matthew Rosencrans
CPC/NWS/NOAA



<http://droughtmonitor.unl.edu/>



**U.S. Drought Monitor
CONUS**



March 17, 2015
(Released Thursday, Mar. 19, 2015)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	46.05	53.95	34.73	16.24	9.02	3.17
Last Week 3/10/2015	47.36	52.64	31.60	15.73	8.39	3.17
3 Months Ago 12/16/2014	59.29	49.71	30.05	17.27	6.05	2.40
Start of Calendar Year 1/1/2015	53.20	46.80	26.60	16.93	9.96	2.54
Start of Water Year 10/1/2014	52.22	47.78	30.57	18.66	8.41	3.65
One Year Ago 3/16/2014	48.53	51.47	37.48	22.27	8.47	1.64

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

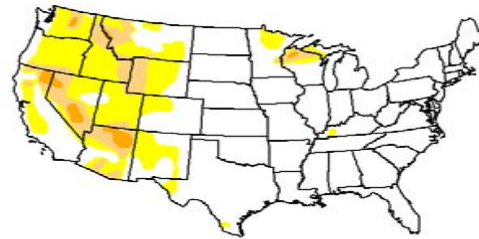
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Chris Fenimore
NCDC/NESDIS/NOAA



<http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



March 2, 2010
(Released Thursday, Mar. 4, 2010)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	72.23	27.67	8.83	1.56	0.00	0.00
Last Week 2/23/2010	71.86	28.14	9.03	1.59	0.00	0.00
3 Months Ago 12/10/2009	72.91	27.09	13.11	5.22	0.47	0.00
Start of Calendar Year 1/1/2010	72.07	27.93	12.40	4.24	0.19	0.00
Start of Water Year 10/1/2009	63.90	36.01	14.98	6.18	1.30	0.28
One Year Ago 3/2/2009	47.07	52.93	25.69	8.70	2.29	0.85

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

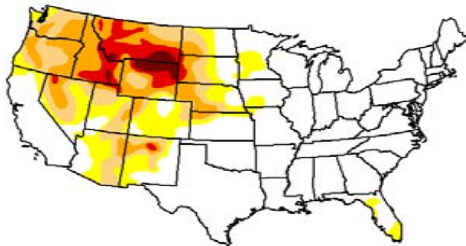
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Richard Tenker
CPC/NOAA/NWS/NCEP



<http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



March 1, 2005
(Released Thursday, Mar. 3, 2005)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	61.65	38.35	26.70	16.26	5.51	1.32
Last Week 2/22/2005	60.35	39.65	27.17	15.40	5.84	1.04
3 Months Ago 11/30/2004	62.82	37.18	25.99	15.72	5.49	0.93
Start of Calendar Year 1/1/2005	63.03	36.97	25.64	15.30	5.91	0.77
Start of Water Year 10/1/2004	56.52	43.48	30.51	21.82	9.69	0.93
One Year Ago 3/1/2004	48.60	51.40	39.18	26.26	12.54	2.06

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

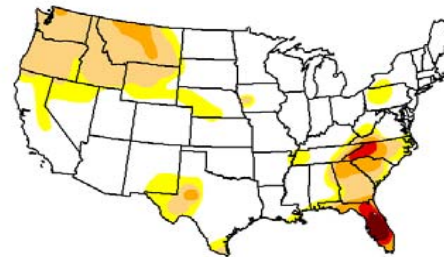
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
Richard Heim
NCDC/NOAA



<http://droughtmonitor.unl.edu/>

**U.S. Drought Monitor
CONUS**



March 6, 2001
(Released Thursday, Mar. 8, 2001)
Valid 7 a.m. EST

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	66.74	33.26	21.24	5.40	1.86	0.71
Last Week 2/27/2001	65.21	34.79	21.65	5.64	1.74	0.73
3 Months Ago 12/6/2000	66.14	33.86	16.75	9.06	0.81	0.14
Start of Calendar Year 1/1/2001	70.82	29.18	13.94	6.16	0.96	0.33
Start of Water Year 10/1/2000	42.19	57.81	38.28	23.95	6.90	0.74
One Year Ago 3/6/2000	45.92	54.08	32.17	15.08	0.00	0.00

Intensity:
■ D0 Abnormally Dry ■ D3 Extreme Drought
■ D1 Moderate Drought ■ D4 Exceptional Drought
■ D2 Severe Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author(s):
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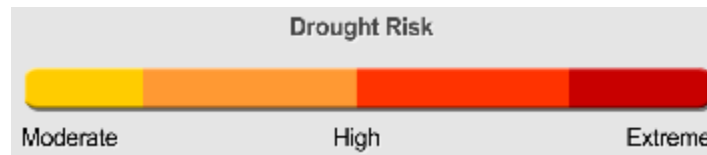
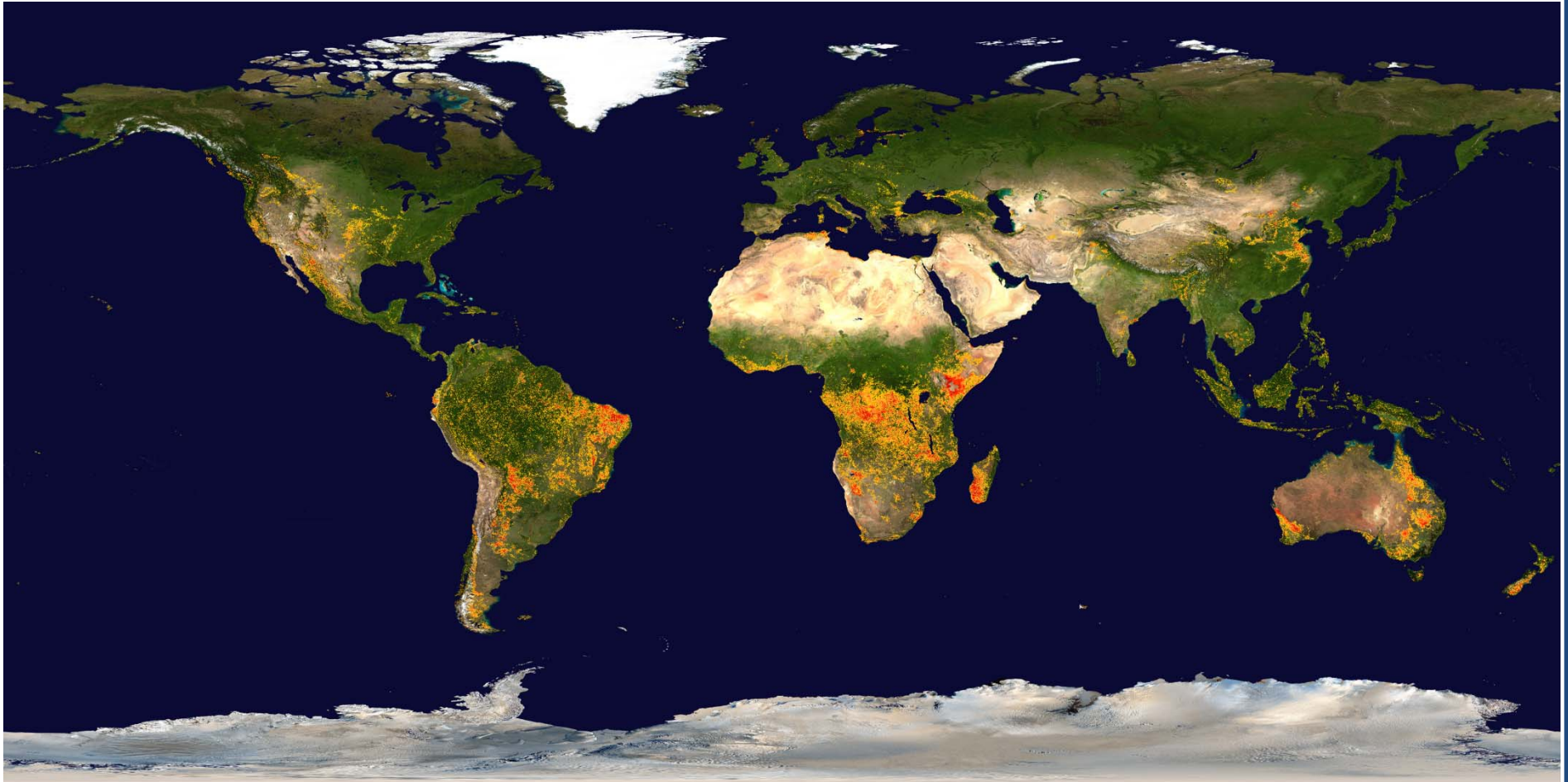
<http://droughtmonitor.unl.edu/>



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<http://www.eldoradocountyweather.com/climate/world-maps/world-drought-risk.html>

Water Resources and Water Use Reduction at Thermoelectric Plants

- Dry or water-efficient cooling
 - Advanced materials with improved heat transfer properties
 - Novel air-flow designs
 - Systems optimization and control
- Alternatives to water as a working fluid
- Water-efficient CCS technologies
- Water recovery from plant operations (e.g. coal drying, stacks)
- Effective fuel use to reduce the need for cooling
 - Systems/ technologies for energy utilization from low grade waste heat
 - Alternate (more energy-efficient) power cycles



Treatment and Management of Nontraditional Waters

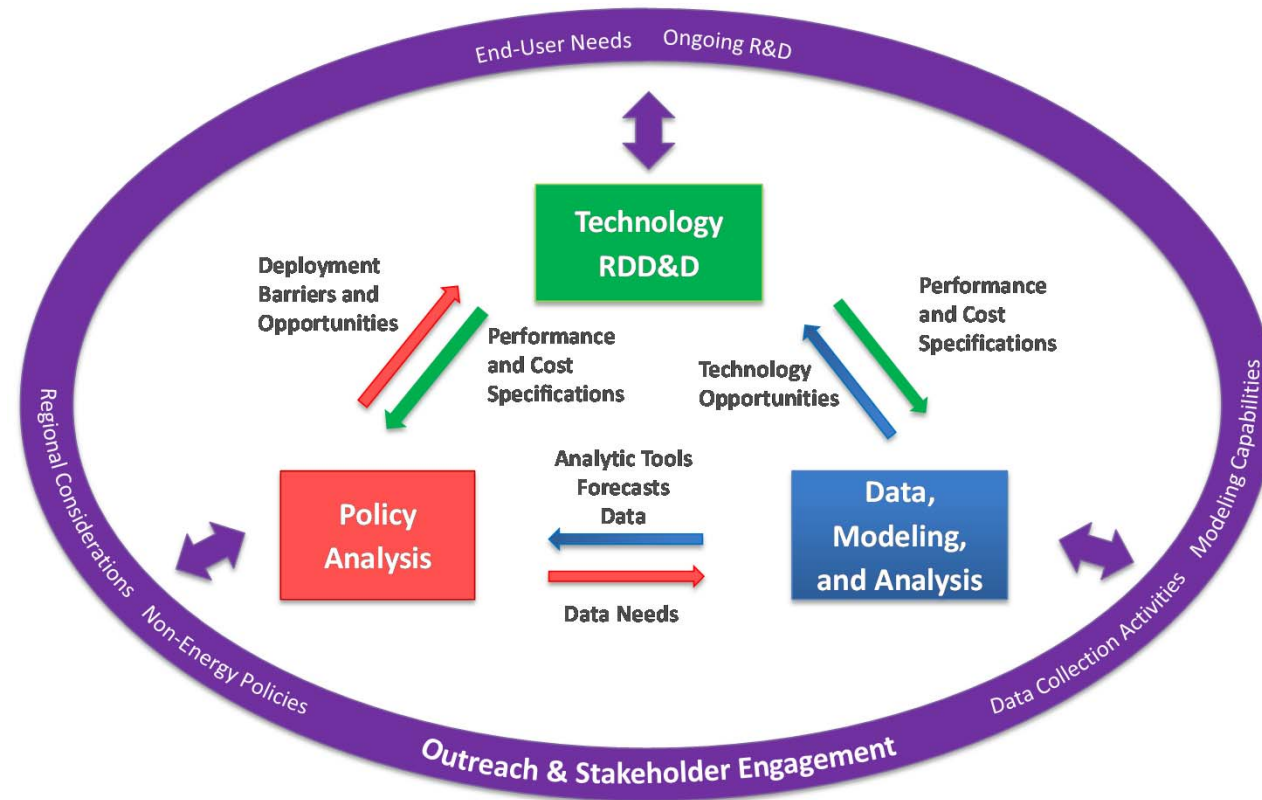
- Advanced technologies (e.g. forward osmosis, nanofiltration, membrane distillation, capacitive deionization, reverse electrodialysis, pressure-retarded osmosis)
- System optimization, including tunable water treatment systems (to varying quality of water resource input/ desired output)
- Alternate energy sources: e.g. waste heat, low temperature geothermal, low temperature concentrating solar power, pressure/ temperature differentials, co-produced natural gas
- Modeling and analysis to inform water resource protection in energy development
- Sensor systems for real time measurement of water quality and quantity in energy operations



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DOE Water Tech Team



DOE Water Energy Nexus Full Report Challenges and Opportunities July 2014

[http://www.energy.gov/sites/prod/files/2014/07/f17/Water
Energy Nexus Full Report July 2014.pdf](http://www.energy.gov/sites/prod/files/2014/07/f17/Water_Energy_Nexus_Full_Report_July_2014.pdf)



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Rare Earth Elements

Report to Congress on the economic feasibility of the recovery of rare earth element for coal, coal ash and byproducts.



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