Connecticut Energy, Environment and Economic Development Conference:

Keeping the Lights On

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Connecticut Energy, Environment and Economic Development Conference:

Keeping the Lights On

Panel I: Climate Adaptation, EPA Rules and the New England Electrical Grid

Climate Control Adaptation EPA Rules and the Electrical Grid

Leading to a Cleaner and Smarter Generation Mix

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Climate Adaptation Management is an Administration Priority

In absence of congressional action addressing greenhouse gas emissions (GHGs) and Climate Impairment , the President took executive action in 2009. He established the Climate Change Adaptation Interagency Task Force (EPA and 19 other agencies). EPA takes lead under former CT DEP Comm.

1. 12/2009 EPA finds Greenhouse Gas (GHGs) constitute a threat to public health (the endangerment finding) CAA
2. 1/2010 EPA directs that climate change adaptation be integrated into programs, policies, rules and operations
3. 5/2010 EPA issues the "Tailoring Rule" requiring New Source Review (NSR) for major sources of GHGs CAA
4. 3/2012 EPA proposes Carbon Std (NSPS) for new power plants (imposes CCS on coal gas equivalent) 30 year avg. CAA

   Imposes SIP measures on existing facilities

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Other Rules Available to EPA for Climate Adaptation Management

5. Mercury Air Toxics Rule (MATS, 12/2011) CAA

   (big $ for haz air emissions reductions 3, 4 or 5 yrs for compliance , 10GWs of retirements)

6. Proposed 316b rule final NLT 6/27/13 CWA

   applies to H2O intake for protection of fish, larvae and eggs. If cooling towers become the common solution , EEI estimates that retirements could be increased by 40% (25 GWs to 40GWs).

7(a) NSPS for Internal Combustion Engines (ICE NSPS)

7(b) NESHAPs for Reciprocating Internal Combustion Engines (RICE NESHAPS), 1/30/13 CAA

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Other EPA Rules in the Making

8. Effluent Standards Under Development (post 2015) **CWA**
   - Toxic metals in waste waters from coal activities, FGD, cooling towers, and chemical use is the motivator
   - apply treatment technologies to meet stricter limits
9. Coal Combustion Residual Rule (post 2015) **RCRA**
   - option 1: treat as a special -hazardous waste subject under requirements of sub title C of RCRA
   - option 2: treat as a non-hazardous waste sub D of RCRA

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New and More Constraining National Ambient Air Quality Standards

- NO2 1 hour at 100ppb (can be trouble for NGCC)
- SO2 1hour at 75 ppb (requires revision of SIPs)
- PM2.5 Annual at 12ug/ cu meter
- Mandatory Reconsideration of the Ozone STD currently at 75 ppb could go to 60ppb **

** passions run high in TX and SE but reconsideration of the standard is required by law.

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CSAPR Vacated but not Buried
Modest Set Back for the Ozone and Acid Rain Fighting Ghost (CSPAR 2 2015 or latter)

- Cross State Air Pollution Rule (CSAPR)was vacated by the court and then upheld on appeal
- EPA will address court's cited flaws with a CSAPR II (2015 or latter)
- CSPAR II will address new PM2.5 and Ozone STD (2013)
- CSAPR II will be more restrictive/onerous than CSPAR 1 because of stricter PM2.5 and Ozone STD

CSAPR II (ozone 60ppp) on the heels NSPS GHGs and 316b would be the "coup de grace" for coal

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The EPA Has Climate Adaptation Allies ??

1. State RPS Standards and Goals (31 states)
2. Regional Greenhouse Gas Initiative (RGGI) as amended
3. Midwestern Greenhouse Gas Reduction Accord
4. Western Climate Initiative
5. AB32 California Cap-and Trade Regulation
6. FERC Order 1000 and other FERC judgments
7. Energy Efficiency “No Brainer”
8. Demand Response (not so fast)
9. Cheap Natural Gas Availability (some disagree, fracking)

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ICE NSPS and RICE NESHAPS and Demand (DR)

DR (users reduce load for reliability or economic reasons)

1. Allows the use of Generators to be part of Demand Response
   - (a) emergency demand response
   - (b) economic demand response (peak shaving)
2. Why DR : it is an available resource that can enhances the stability and reliability of the Grid without costly additions of new infrastructure (generation or transmission)

Did EPA infuse Climate Adaptation thinking into these rules? Our First Speaker, Don DiCristofaro will be address this issue.

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The New England GRID at a Glance
45, 20, 7,13,1

- 37,000 MWs of Available Capacity (35% RM and strong RPS)
- 8000 miles of Transmission lines (congestion is a concern)
- 12000 MWs Potential Wind (8 GW onshore, 4 GW offshore)
- Overdependence on Natural Gas (No Shale Gas)

  ^ options are to increase pipeline cap or be dual fuel for CC
- 10 GWs of vulnerable older Plants (oil , coal , Vt. Yankee)
- Aggressive Transmission Upgrades ($ BB)
- Several N-S Transmission Proposals (RPS driven, imports)
- 2-3 GWs of DR potential (10% of peak demand)

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New EPA Engine Rules To Keep the Lights On

Don DiCristofaro, Blue Sky Environmental LLC
Consultant to EnerNOC
March 13, 2013

Agenda

- Some History
- RICE NESHAP Rule Changes
- How this Affects Engine Use in CT
- Climate Adaptation

First Approached EPA in 2008

Stationary CI ICE used to supply power to an electric grid or that supply power as part of a financial arrangement with another entity are not considered to be emergency engines.

Original NSPS

- July 2008 Meeting with EPA Region I
- Proposed RICE NESHAP contained Same Sentence, 2009
- High Level EPA Meeting January 2010
- RICE NESHAP issued March, 2010 with 15 Hour Emergency DR Limit
- EnerNOC filed Petitions for Reconsideration and Review May, 2010
- EPA Requests for Comments (Five Separate Requests)
- Public Meeting January, 2011
- EPA settles December, 2011
- Proposed Rule Changes, June 2012 and Public Hearing July, 2012
- Revised rules published in Federal Register, January 2013

What is the EPA RICE NESHAP Rule?

- National Emission Standards for Hazardous Air Pollutants (NESHAP)
- Covers both Compression Ignition (CI) and Spark Ignition (SI) Reciprocating Internal Combustion Engines (RICE)
- Regulates emissions from stationary RICE at both major and areas sources of hazardous air pollutants (HAPs)
- This presentation will focus on area sources of HAPs at non-remote locations
- For area sources, NESHAP applies to existing engines that were ordered/installed prior to June 12, 2006; newer engines operate under the NSPS (New Source Performance Standards)
- EPA final rules were published on January 30, 2013 for both RICE NESHAP and NSPS

Use of Engines in Demand Response

- Emergency Demand Response (DR)
  - Used as measure of last resort
  - Program called by ISO either at the start of voltage reductions (e.g., ISO NE) or just prior to voltage reductions (e.g., PJM, ERCOT)
  - Although emergency DR is rarely called, engines need to be available more than 15 hrs/yr to meet FERC tariff requirements
- Non-Emergency DR or Peak Shaving
  - Can be called by the utility for both emergency and non-emergency (e.g., economic) reasons

Regulators Recognize the Value of Emergency DR

Most permitting agencies allow the operation of emergency engines for emergency DR

Regions that currently support emergency DR in air regulations	
• Connecticut* • Massachusetts* • Vermont* • Rhode Island* • New Hampshire* • Maine • New York • Ohio*	• Pennsylvania (all but Philadelphia County) • Maryland* • Virginia* • West Virginia • Illinois • Indiana • Michigan • Texas
Regions that do not currently support emergency DR in air regulations	
• Delaware • New Jersey	• Philadelphia County, PA • Washington, DC

*States noted with * required regulatory change to facilitate emergency DR participation by emergency engines*

EPA's Arguments for RICE NESHAP

As noted by EPA in the Federal Register Notice (January 30, 2013).

*"The EPA believes that the emergency demand response programs that exist across the country are important programs that **protect the reliability and stability of the national electric service grid**."*

*"The use of stationary emergency engines as part of emergency demand response programs can help prevent grid failure or blackouts, by **allowing these engines to be used for limited hours** in specific circumstances of grid instability prior to the occurrence of blackouts."*

*"A standard that requires owners and operators of stationary emergency engines that participate in emergency demand response programs to apply after treatment could make it economically infeasible for these engines to participate in these programs, impairing the ability of regional transmission organizations and independent system operators to use these relatively small, quick-starting and reliable sources of energy to protect the reliability of their systems **in times of critical need**."*

EPA on RICE NESHAP (Continued)

On the question of whether or not emergency demand response events are likely to be called on poor air quality days…

"While the EPA is sensitive to these concerns, the availability of these engines for a more tailored response to emergencies may be ***preferable in terms of air quality impacts than relying on other generation, including coal-fired spinning reserve generation****."*

- Federal Register Notice (January 30, 2013)

"While EPA acknowledges that emergency DR may be called during HEDD in the summer when days are especially warm and ozone is problematic, ***the use of emergency DR at such times cannot be directly correlated as causing or contributing to the ozone exceedances****. Also, the fact is that many DR events occur on days when ozone standards were not exceeded and in many cases ozone levels are high or higher on days before a DR event, according to available data."*

- EPA RICE NESHAP Response Comments (January 14, 2013)

Determining the Impact of Emission Standards

There are many factors in determining whether back-up generators in DR programs are affected.

Emission Standards: Existing RICE Located at Area Sources

HP	Engine Subcategory					
	Non-emergency					Emergency or Black start
	CI	SI 2SLB	SI 4S in remote areas	SI 4S not in remote areas	SI LFG/DG	
≤300	Change oil/filter & inspect air cleaner every 1,000 hours or annually; inspect hoses/belts every 500 hours or annually	Change oil/filter, inspect spark plugs, & inspect hoses/ belts every 4,320 hours or annually	Change oil/ filter, inspect spark plugs, & inspect hoses/belts every 1,440 hours of operation or annually	Change oil/ filter, inspect spark plugs, & inspect hoses/belts every 1,440 hours of operation or annually	Change oil/ filter, inspect spark plugs, & inspect hoses/ belts every 1,440 hours of operation or annually	Change oil/filter & inspect hoses/ belts every 500 hours or annually; inspect air cleaner (CI) or spark plugs (SI) every 1,000 hours or annually
300-500	49 ppm CO or 70% CO reduction					
>500	23 ppm CO or 70% CO reduction		Change oil/ filter, inspect spark plugs, & inspect hoses/belts every 2,160 hours of operation or annually	If engine used >24 hrs/yr: 4SLB: Install oxidation catalyst 4SRB: Install NSCR		

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Acronyms & Definitions

- **CI**: *Compression Ignition (diesel)*
- **SI**: *Spark Ignition (e.g., natural gas, propane, gasoline, landfill gas)*
- **2SLB**: 2 Stroke Lean Burn
- **4SLB**: 4 Stroke Lean Burn
- **4SRB**: 4 Stroke Rich Burn
- **LFG/DG**: Landfill gas/digester gas
- **2 Stroke**: Power cycle completed in one revolution of crankshaft
- **4 Stroke**: Power cycle completed in two revolutions of crankshaft
- **Lean Burn**: Higher air/fuel ratio (fuel lean)
- **Rich Burn**: Lower air/fuel ratio (fuel rich)
- **CO**: Carbon Monoxide
- **CH2O**: Formaldehyde

Key Rule Change: 100 Hour Usage

Back-up generators can run up to 100 hours/year for any combination of:

- **Testing & Maintenance**
- **Emergency DR** – *defined in Slide 11*
- **"Non-Emergency" Situations** (50 of the 100 hours/year) – *defined in Slide 12*
  - What EPA defines as "non-emergency" is actually emergency DR for transmission and distribution- level emergencies
- **Peak Shaving or Non-Emergency DR** (50 of the 100 hours/year, and only until May 2, 2014) – *defined in Slide 13*

EPA Language

"(2) You may operate your emergency stationary RICE for any combination of the purposes specified in paragraphs (f)(2)(i) through (iii) of this section for a maximum of 100 hours per calendar year. Any operation for non-emergency situations as allowed by paragraphs (f)(3) and (4) of this section counts as part of the 100 hours per calendar year allowed by this paragraph (f)(2)."

Reference: NESHAP (63.6640(f)(2)), NSPS (IIII) (60.4211(f)(2)), NSPS (JJJJ) (60.4243(d)(2))

Emergency DR

The key triggers are:

- NERC Energy Emergency Alert (EEA) Level 2; OR
- 5% Deviation of Voltage or Frequency

EPA Language

*"(ii) Emergency stationary RICE may be operated for emergency demand response for periods in which the Reliability Coordinator under the North American Electric Reliability Corporation (NERC) Reliability Standard EOP-002-3, Capacity and Energy Emergencies (incorporated by reference, see §63.14), or other authorized entity as determined by the Reliability Coordinator, has declared an **Energy Emergency Alert Level 2** as defined in the NERC Reliability Standard EOP-002-3.*

*(iii) Emergency stationary RICE may be operated for periods where there is a **deviation of voltage or frequency of 5 percent or greater below standard voltage or frequency**."*

Reference: NESHAP (63.6640(f)(2)), NSPS (IIII) (60.4211(f)(2)(ii)), NSPS (JJJJ) (60.4243(d)(2)(ii))

“Non-Emergency” Situations

Specific requirements must be met to be eligible for operation of up to 50 hours (out of 100 hours/year) in transmission or distribution-level emergencies.

- Subsection B (T&D Limitations) is key and utility-specific

EPA Language

“(ii) The 50 hours per year for non-emergency situations can be used to supply power as part of a financial arrangement with another entity if all of the following conditions are met:

(A) The engine is dispatched by the local balancing authority or local transmission and distribution system operator.

(B) The dispatch is intended to mitigate local transmission and/or distribution limitations so as to avert potential voltage collapse or line overloads that could lead to the interruption of power supply in a local area or region.

(C) The dispatch follows reliability, emergency operation or similar protocols that follow specific NERC, regional, state, public utility commission or local standards or guidelines.

(D) The power is provided only to the facility itself or to support the local transmission and distribution system.

(E) The owner or operator identifies and records the entity that dispatches the engine and the specific NERC, regional, state, public utility commission or local standards or guidelines that are being followed for dispatching the engine. The local balancing authority or local transmission and distribution system operator may keep these records on behalf of the engine owner or operator.”

Reference: NESHAP (6640(f)(4)(ii)), NSPS (IIII) (60.4211(f)(3)(i)), NSPS (JJJJ) (60.4243(d)((3)(i))

Peak Shaving or Non-Emergency DR

- 50 hours of operation per year (as part of the total 100 hours/year) are permitted through May 2, 2014 ONLY
- **Starting May 3, 2014, all back-up generators used in traditional peak-shaving, economic, or other non-emergency DR programs must meet NESHAP non-emergency requirements**

EPA Language

"(i) Prior to May 3, 2014, the 50 hours per year for non-emergency situations can be used for peak shaving or non-emergency demand response to generate income for a facility, or to otherwise supply power as part of a financial arrangement with another entity if the engine is operated as part of a peak shaving (load management program) with the local distribution system operator and the power is provided only to the facility itself or to support the local distribution system."

Reference: NESHAP (6640(f)(4)(i))

Determining the Impact of Emission Standards

There are many factors in determining whether back-up generators in DR programs are affected.

Emission Standards: Existing RICE Located at Area Sources

HP	Engine Subcategory					
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Serious Consequences for Exceeding Limits

Exceeding limits will be treated as violations of the Clean Air Act.

- EPA removed the “once a non-emergency engine, always a non-emergency engine” clause and will now handle on a case-by-case basis

EPA Language

“If you do not operate the engine according to the requirements in paragraphs (f)(1) through (4) of this section, the engine will not be considered an emergency engine under this subpart and must meet all requirements for non-emergency engines.”

Reference: NESHAP (6640(f)), NSPS (IIII) (60.4211(f)), NSPS (JJJJ) (60.4243(d))

ENERNOC

New Requirements

- Starting in 2015, generator owners need to start using ULSD – not emptying existing tanks, but for all new purchases
- Annual reports starting with calendar year 2015 and must be submitted no later than March 31, 2016.
- Valid for Emergency CI >100 HP and contractually obligated >15 hours/year for emergency DR or “non-emergency” operations

Operating Engines in Connecticut

Need to follow more stringent of state and federal regulations

- Connecticut DEEP Air Regulations
  a) R.C.S.A. 22a-174-3a (individual air permit)
  b) R.C.S.A. 22a-174-3b (permit exemption if meet 300 hours/yr (rolling 12-month average) and 0.3% sulfur or less)
  c) R.C.S.A. 22a-174-3c (permit exemption if meet fuel limits (e.g., 21,000 gals/yr diesel (calendar year))
  d) R.C.S.A. 22a-174-42. Distributed Generators
  e) None of the above if potential to emit (PTE) of pollutants < 15 tons per year (based on 8,760 hours)

- NESHAP/NSPS
  100 hours/year (calendar year) for testing/maintenance/emergency DR
  Unlimited lights out operations
  ULSD and annual reports starting 2015 if in emergency DR

Emergency DR and Climate Adaptation

- Reduces reliance on coal-fired spinning reserves
- Availability of existing, quick start resources reduces need to build new power plants that may only be used a few hours or less per year
- DR also includes curtailment (e.g., turning off lights, air conditioning, manufacturing processes)
- Helps stabilize the electric grid

Don DiCristofaro
(ddicristofaro@enernoc.com

David Crane, NRG CEO, Comments on the Future of Electric Industry

Yale Environment 360 Interview and Comments at the 2013 MIT Energy Conference

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NRG Energy at a Glance

NRG : 47, 000 MW (50% East, 35 % Gulf and 15% West)

- **54% Natural Gas**
- **28% Coal**
- **13% Oil**
- **3% Renewables (Wind and Solar)**

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A Trioka of Game Changers

Profound Energy Market Transformation coming

(1) Solar Panels on Roofs

(2) Electric Cars in Your Garage

(3) Smart Meters (transfer e to and from the grid)

His long term Hope/Vision

USA will kick the imported oil habit and run on electricity from renewable sources (particularly) solar on roof tops.

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Climate Change and Politics

- **DC is completely polarized**
- **Need bipartisan support as was the case for the 1990 CAA and 2005 Energy Bill**
- **Not Much Progress on Climate Change after the Optimism of 2008 Election**
- **Believes that the Solution is from the Private Sector**
- **Give American's an Energy Choice**

Don't have to settle for electricity from coal or gasoline from imported oil. Don't talk green as expensive –look forward to when electric vehicles are solar panels are the best options.

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Transportation is the Biggest Opportunity

- Various forms of Energy are in Competition—we have vast resources available to us.
- Transportation is 100% oil All Americans want to stop importing Middle East oil, so he sees a huge public policy benefit by switching vehicles not powered by imported gasoline (electric car is his choice).
- Sees a big market in the 60 million Americans that own just two cars. Thinks that the electric car is a natural choice for a 2nd car.

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Has Passion For Solar

- Sees a future for Utility Scale Solar but believes that there will be explosive growth in distributed solar (1 to 10 MW) and residential (measured in kilowatts)
- Have Done a parking lot project with Redskins and have covered 800 parking spaces with panels. That is enough to power stadium on non event days,
- Distributed Solar needs fair and generous net metering.

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Prefers Solar to Wind

- Thinks that in 3 to 5 years that electricity from roof top solar panels will be cheaper than electricity from the Grid.

- Not as enthusiastic about Wind(calls wind turbines engineering marvels, “monstrously large”)

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Other Views

- Thinks Nuclear has to be in the mix if our goal is a solution to climate change. NRG is looking to build a 27 MW Nuclear plant in Bay City Texas
- Sees natural gas as a short term climate remedy. Can't get to the 2050 goal of 80 % carbon reduction with gas.
- Sees no future for coal!
- "It's now up to business to show Americans that clean energy is not a high-cost proposition, but a smart way forward"
- DOE not EPA should lead the charge

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Advancing the New England Electric Grid: Clean Energy, Natural Gas & Innovation

Connecticut Energy, Environment and Economic Development Conference

March 13, 2013

Peter Rothstein, President
New England Clean Energy Council

Mission & Role

- ***New England Clean Energy Council*** (NECEC, a 501(c)(6) trade member organization) is the lead voice for hundreds of clean energy companies across New England, influencing the energy policy agenda and growing the clean energy economy
  - NECEC leads efforts in Policy, Government Affairs, Communications, Member Benefits and Stakeholder Engagement

- ***NECEC Institute*** (a 501(c)(3)) is a leader in programs that support the emergence and growth of new clean energy companies
  - NECEC Institute executes projects in Innovation, Cluster Research & Economic Development and Education & Workforce Development

- As sister entities under the ***NECEC*** umbrella, we share a mission to:
  - ***Accelerate New England's clean energy economy to global leadership by building an active community of stakeholders and a world-class cluster of clean energy companies***

Grid Modernization & Clean Energy While Leveraging Low Gas Prices

- Related themes in Grid Modernization, Clean Energy, Economics:
  - Grid modernization – new network architecture, standards, technologies, pricing, distributed intelligence, storage, DR, microgrids, etc.
  - Efficiency returns
  - Renewables trends
  - Natural gas impacts
  - Adding innovation
  - System investments models and future scenarios
- How do we cost-effectively invest in modernization?

Clean Energy Driven by Multi-Year Policies & Economics

- Efficiency:
  - Comprehensive Energy Plan calls for "all cost-effective" energy efficiency
- Renewables:
  - RPS standard for annual renewables increases drives investment, competition, jobs, cost declines, low-margin generation
- Demand Response:
  - Drives peak reduction and overall savings
- R&D, Innovation investments:
  - Leveraging New England's world-class research universities, industries, innovation economy
- Competing economics:
  - Natural gas supply increases & price declines = retirement of coal & oil from generation mix

- ***Restructured markets + increasing competition for new services + models to support and adopt new innovative***
- ***Impacts benefit customers and regional economy***

Energy Efficiency

- ACEEE 2012 State Energy Efficiency Scorecard
  Strong New England showing:
  - **#1:** Massachusetts
  - **#5:** Vermont
  - **#6:** Connecticut
  - **#7:** Rhode Island
  - **#18:** New Hampshire
  - **#25:** Maine

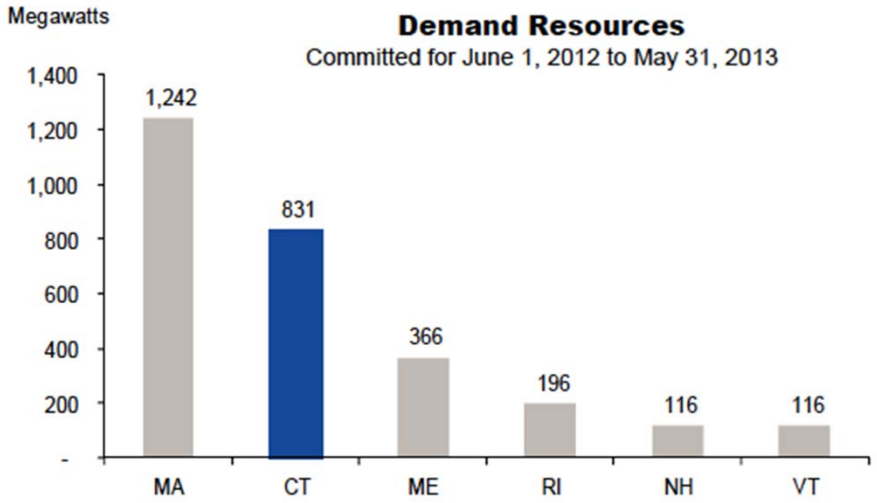
Investing in Energy Efficiency

- Efficiency is the least-cost, “first fuel”
- ISO New England 2012 energy-efficiency forecast:
  - EE forecast shows modest increase in Connecticut energy use with total projected energy savings of over 1.4 billion kilowatt hours by 2021
  - Under EE forecast, energy use in 2021 will be 12% lower than traditional forecast
- ISO forecast does not include additional CT Comprehensive Energy Strategy proposal to expand to “all cost-effective” energy efficiency:
  - All sectors
  - Deeper retrofits
  - Financing innovations
  - Incentivize utilities
  - Building standards
  - Smart grid investments

Source: ISO New England, “Connecticut 2012-13 State Profile”

CT Demand Response Resources

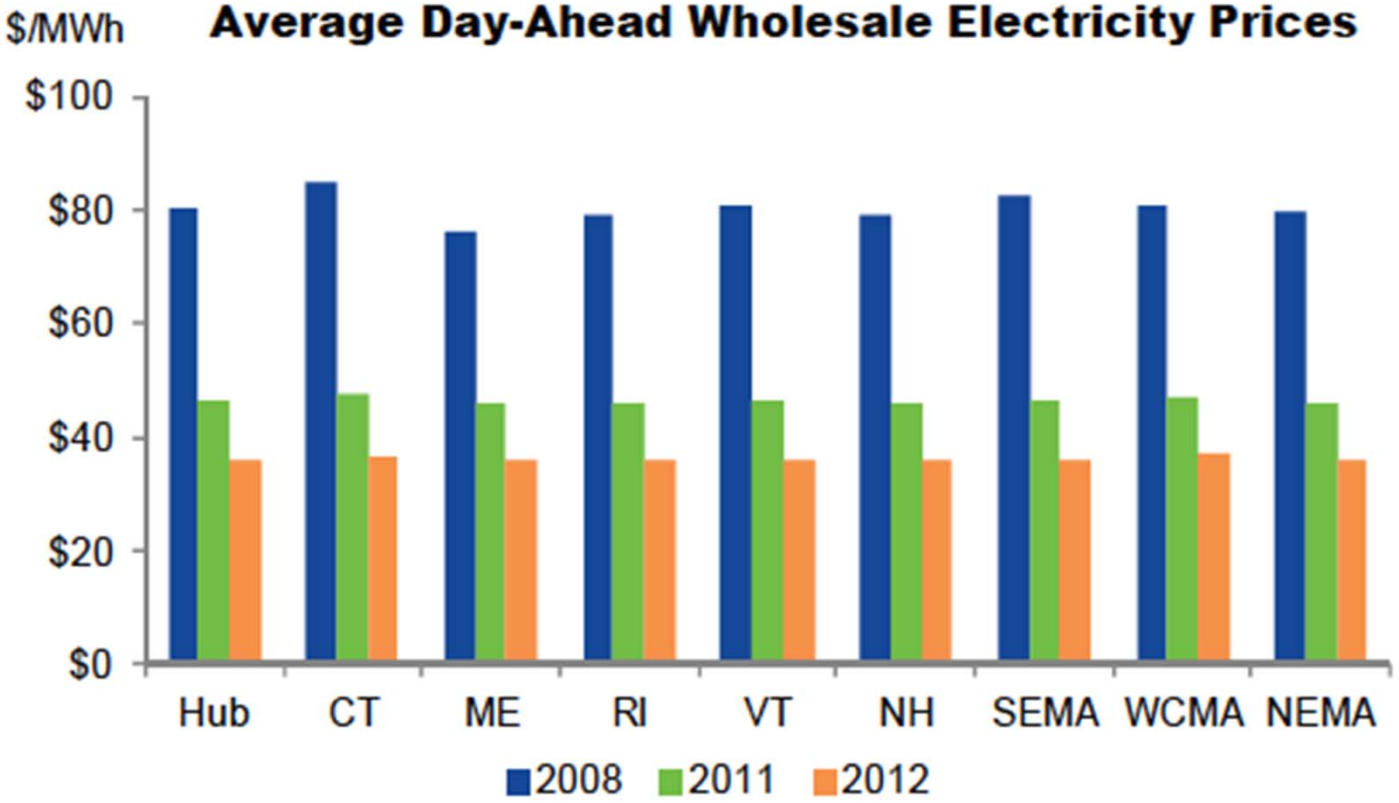
- New England has about 2,900 MW of customer-side Demand Resources (DR)
- Connecticut has over 800 MW of DR with obligations in the FCM, equivalent to 12% of the state's peak demand
- ISO-NE regional forecast for 2015 to 2021 shows:
  - Lower annual growth in peak demand (0.9%) than traditional forecast (1.5%)
  - Annual energy use is flat (0.0%) compared to modest (0.9%) growth under traditional forecast
- Connecticut forecast show slowing growth rate for peak demand:
  - Total projected reduction in peak demand of 193 MW from 2015 to 2021
  - Under EE forecast, peak in 2021 will be 7% lower than traditional forecast



Source: ISO New England, "Connecticut 2012-13 State Profile"

Electricity Prices Declining

- Avg. wholesale prices across New England declined with lower demand and fuel prices
- In 2012, average wholesale electricity prices fell to nearly 23% below prices in 2011, and 26% below prices in 2003, the year that competitive markets in their current form were introduced in the region



Source: ISO New England, "Connecticut 2012-13 State Profile"

Costs are More than KWh Fuel Prices

- Variability
- Predictability & resilience
- Investments in newer, more efficient generation, CHP, energy management, efficient equipment and buildings
- Broader regional economy impacts – regional generation and efficiency produces jobs and regional economic growth

- ***Customers pay bills, not KWh prices***

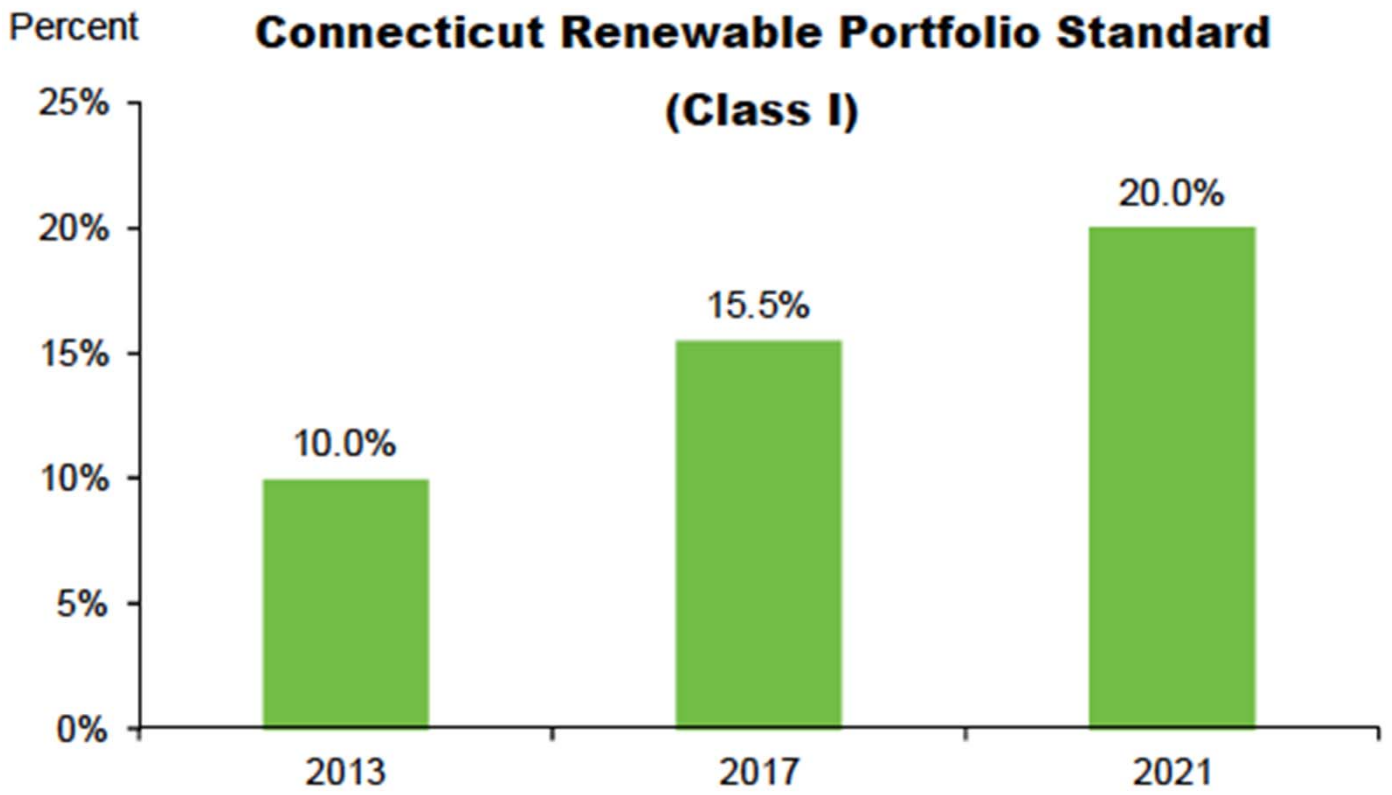
Electricity Bills Declining

- Connecticut had #1 most expensive residential energy prices among lower 48 in 2008, with average residential bills of $143 / month (3rd highest in U.S.)
- Bills declined by 2011 to $134 / month
- Bills declined from 2008 – 2011 from #3 to #5 most expensive in U.S.
- MA comparison:
  - Average MA residential monthly bill dropped from $109 in 2008 at #16, to $93 in 2011 at #35

- ***Natural gas, efficiency, demand response, more competition in renewables all supporting lower / stable bills***
- ***Perfect time to integrate investments in cleaner, smarter grid***

CT RPS Driving Renewables Growth

- Connecticut standards support renewables growth, investments over time, cost declines



Source: ISO New England, "Connecticut 2012-13 State Profile"

Increasing Competitiveness of Renewables

Wind:

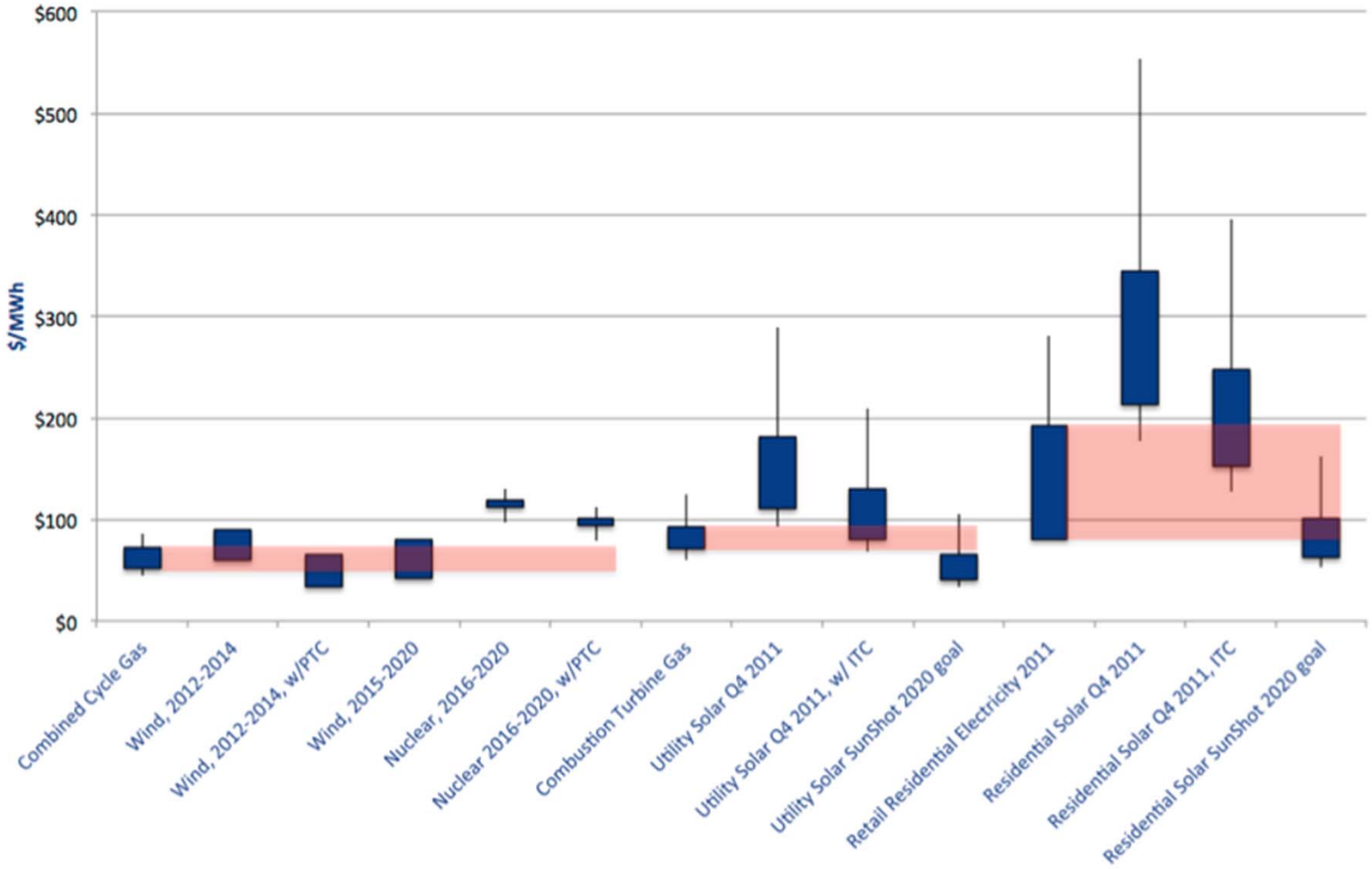
- Analysts estimate that incremental turbine technology improvements have the potential to decrease costs by 10-30 percent in the 2015-2020 period, bringing the unsubsidized levelized cost into the $42-67 per MWh range
- If such innovation occurs, and if natural gas prices inch upwards, wind power could be broadly competitive in that time frame

Solar (DOE Sunshot goals):

- Launched in 2011, DOE SunShot Initiative aims to reduce the price of solar energy systems by about 75% from 2010 and 2020
- Achieving this level of price reductions could result in solar meeting 14% of U.S. electricity needs by 2030 and 27% by 2050
- Realizing these price and installation targets will require a combination of evolutionary and revolutionary technological changes

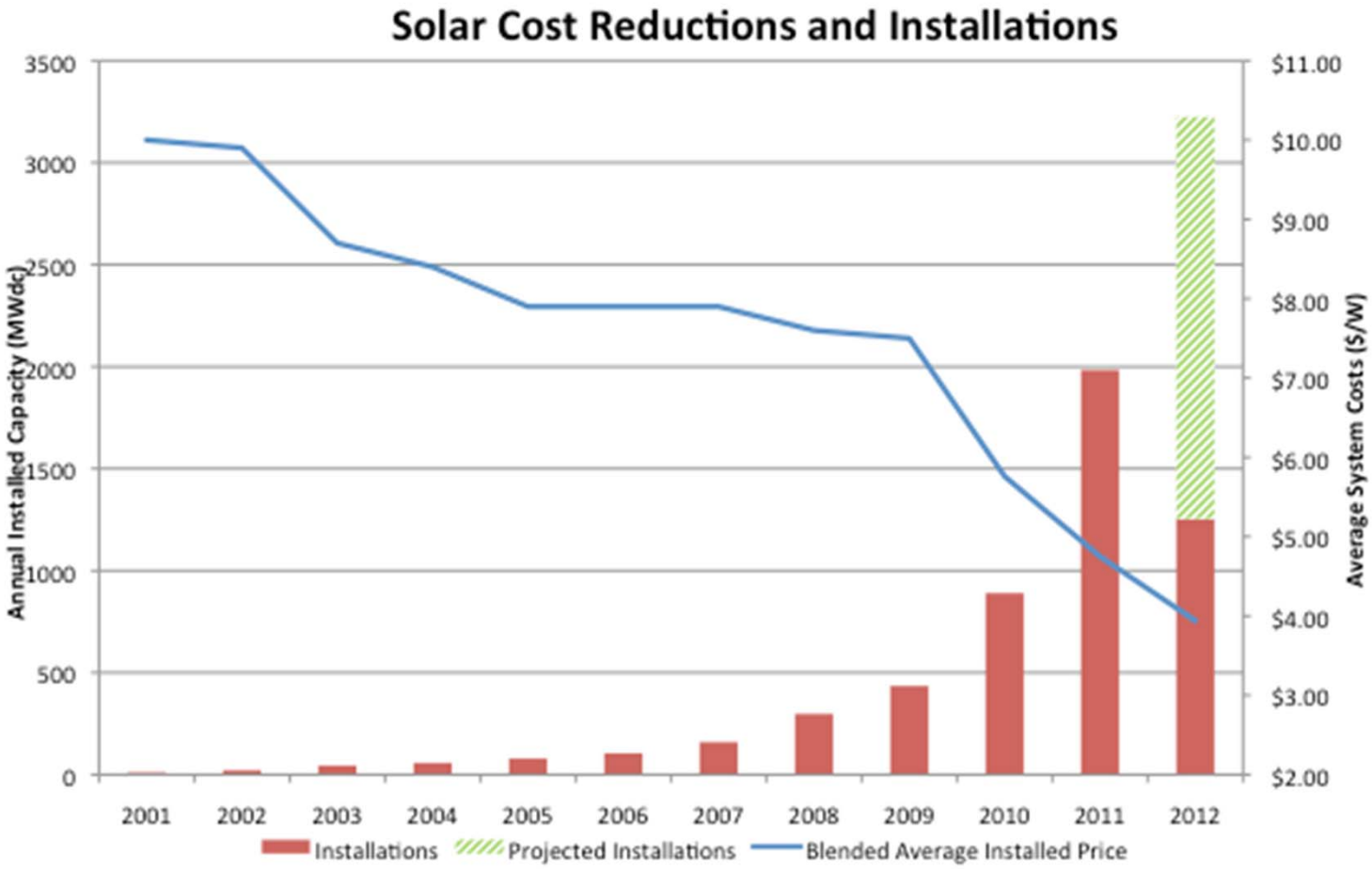
Sources: ***Gas Boom Poses Challenges for Renewables and Nuclear.*** Breakthrough Institute, April 2012, ***DOE Sunshot Vision Study***, 2011

Levelized Cost of Electricity: Renewables Becoming Competitive



Source: ***Gas Boom Poses Challenges for Renewables and Nuclear.*** Breakthrough Institute, April 2012
Red bars indicate the price ranges clean technologies compete against.

Solar Deployment



 Source: US Solar Market Insight Report Q2 2012, GTM Research & SEIA

Grid Modernization: Standards, Technologies, Models

Paradigm Shift → Smart Grid

From:

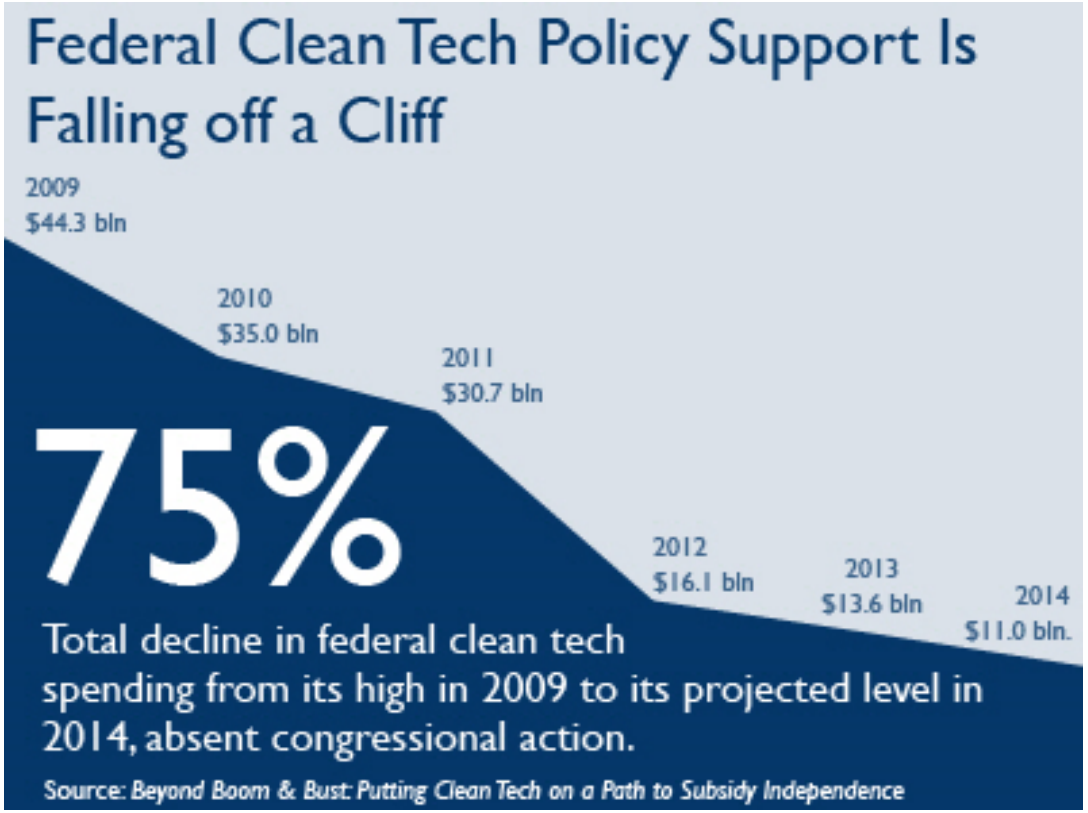
- Vertically integrated monopolies
- Centralized generation
- Limited awareness
- Hierarchical network
- Deterministic control
- Generation to meet demand
- Proprietary architectures and interfaces

To:

- Restructured competitive markets
- More distributed generation
- Sensors everywhere
- Interconnected microgrids
- Stochastic control
- Responsive demand and generation
- Open standards

Source: NIST Smart Grid Program

Challenges: Federal and Private Sector Investments Declines



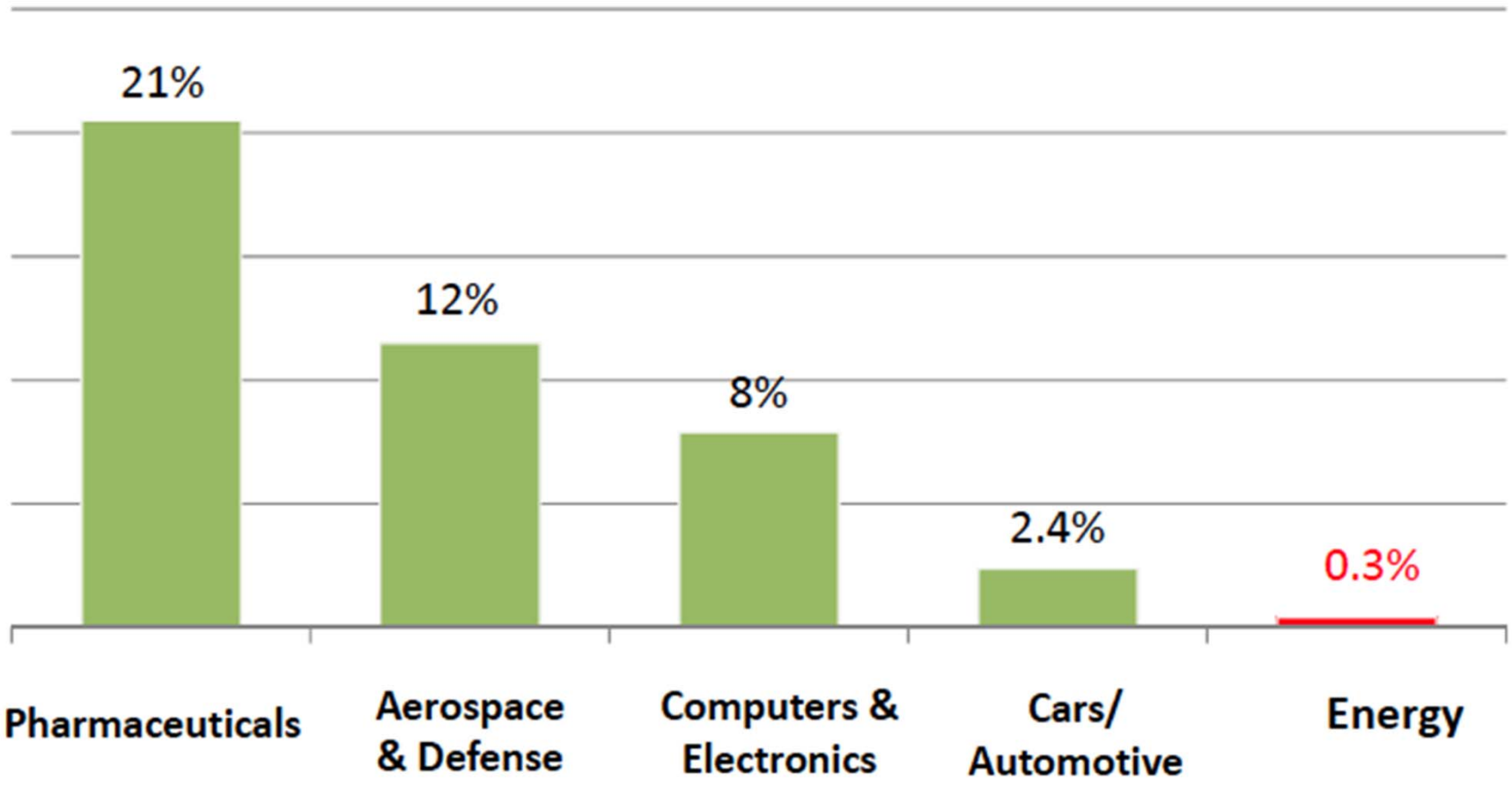
ClimateSpectator

October 10, 2012

Clean energy investment down 20% in 3rd quarter

Private Investment in R&D

(as % of sales)



Source: American Energy Innovation Council, Business Plan for America's Energy Future, 2010

Beyond Next 5 Years:
DOE ARPA-E N.E. Projects Since 2009:
How will next breakthroughs come to market?

ADEPT

BEEST

BEETIT

Electrofuels

GENI

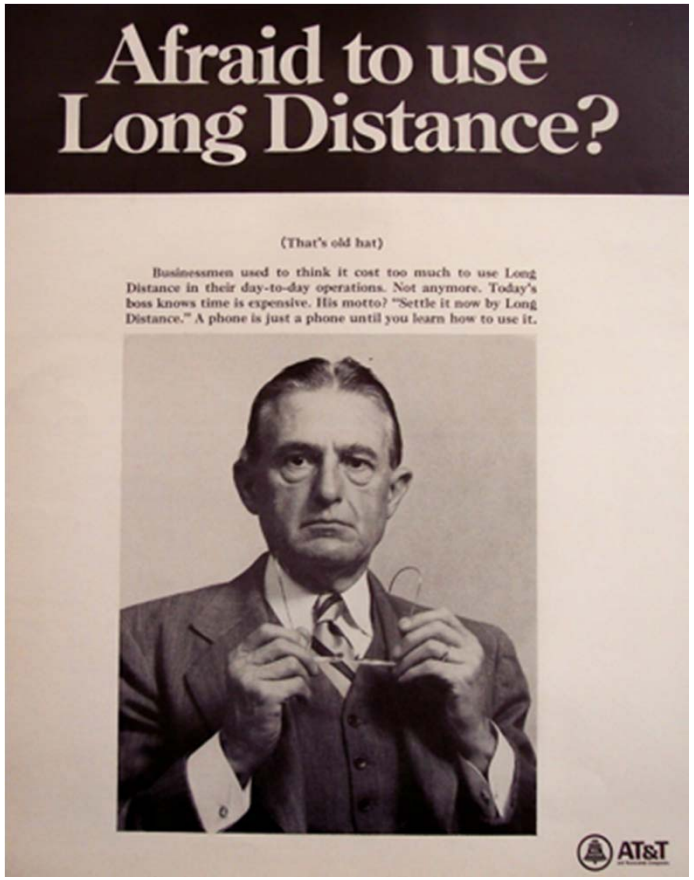
GRIDS

HEATS

IMPACCT

- 1366 Direct Wafer: Enabling Terawatt Photovoltaics
- Advanced Technologies for Integrated Power Electronics
- Advanced Thermo-Adsorptive Battery Climate Control System (ATB)
- Affordable Energy from Water and Sunlight
- Direct Grid Connect Medium Voltage Power Converter for PV utilizing Wide Band Gap Devices
- Bioprocess and Microbe Engineering for Total Carbon Utilization in Biofuel Production
- Breakthrough High Efficiency Shrouded Wind Turbine
- Conditionally activated enzymes expressed in cellulosic energy crops
- Development of a 100 kWh/100 kW Flywheel Energy Storage Module
- Development of a Dedicated, High-Value Biofuels Crop
- Electrochemically Mediated Separation for Carbon Capture and Mitigation
- Electrofuels via Direct Electron Transfer from Electrodes to Microbes
- Electroville: High-Amperage Energy Storage Device-Energy Storage for the Neighborhood
- Engineering a Bacterial Reverse Fuel Cell
- Engineering E. coli as an electrofuels chassis for isooctane production
- Engineering Ralstonia eutropha for Production of Isobutanol (IBT), Motor Fuel from CO2, H2, O2
- Fuel-Free, Ubiquitous, Compressed Air Energy Storage and Power Conditioning
- Hybrid nanostructures for high-energy-density solar thermal fuels
- Low Cost, High Energy and Power Density, Nanotube-Enhanced Ultracapacitors
- Metallic Composites Phase-Change Materials for High-Temperature Thermal Energy Storage
- Multiscale Development of L10 Materials for Rare-Earth-Free Permanent Magnets
- Semi-Solid Rechargeable Power: Flexible, High Performance Storage for Vehicles at Ultralow Cost
- Transmission Topology Control for Integration of Renewable Generation

Learning from Telecom



The old telecommunications paradym: Cents / minute;
A diminishing value prop.

The new telecommunications paradym: Your Personal Device;
Competing on Customer Value

Grid Modernization & Intelligent Services

- Requires attention to customer value & investment returns
- Requires attention to standards
- Requires innovation adoption model
  - Utilities as partners
  - Regulators considering long-term benefits
- Requires attention to economic trends more than historical unit prices
- Requires openness to new pricing models for repackaging of services
- Encourages increased competition

- ***New value for customers and regional economy over time***

Smart Investment in Our Energy System: Clean Energy Market Signals & Policies

- Growth in natural gas availability and reduction in price creates opportunity to underwrite an evolution to a robust, smarter, more cost-effective electricity system
- Incent cost-effective, portfolio investments to stabilize, diversify, leverage regional assets, grow regional competitiveness
- Development mechanisms for new innovations to come to market and have potential to cost-effectively reach scale
- Evolve investments, policies, regulations to reap benefits of a clean economy in Connecticut and across New England

Contact Information

Peter Rothstein
President
prothstein@cleanenergycouncil.org
617-500-9991

Janet Besser
VP Policy & Government Affairs
jbesser@cleanenergycouncil.org
617-500-9994

Kitty Kennedy
VP Operations & Membership
kkennedy@cleanenergycouncil.org
617-500-9992

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