

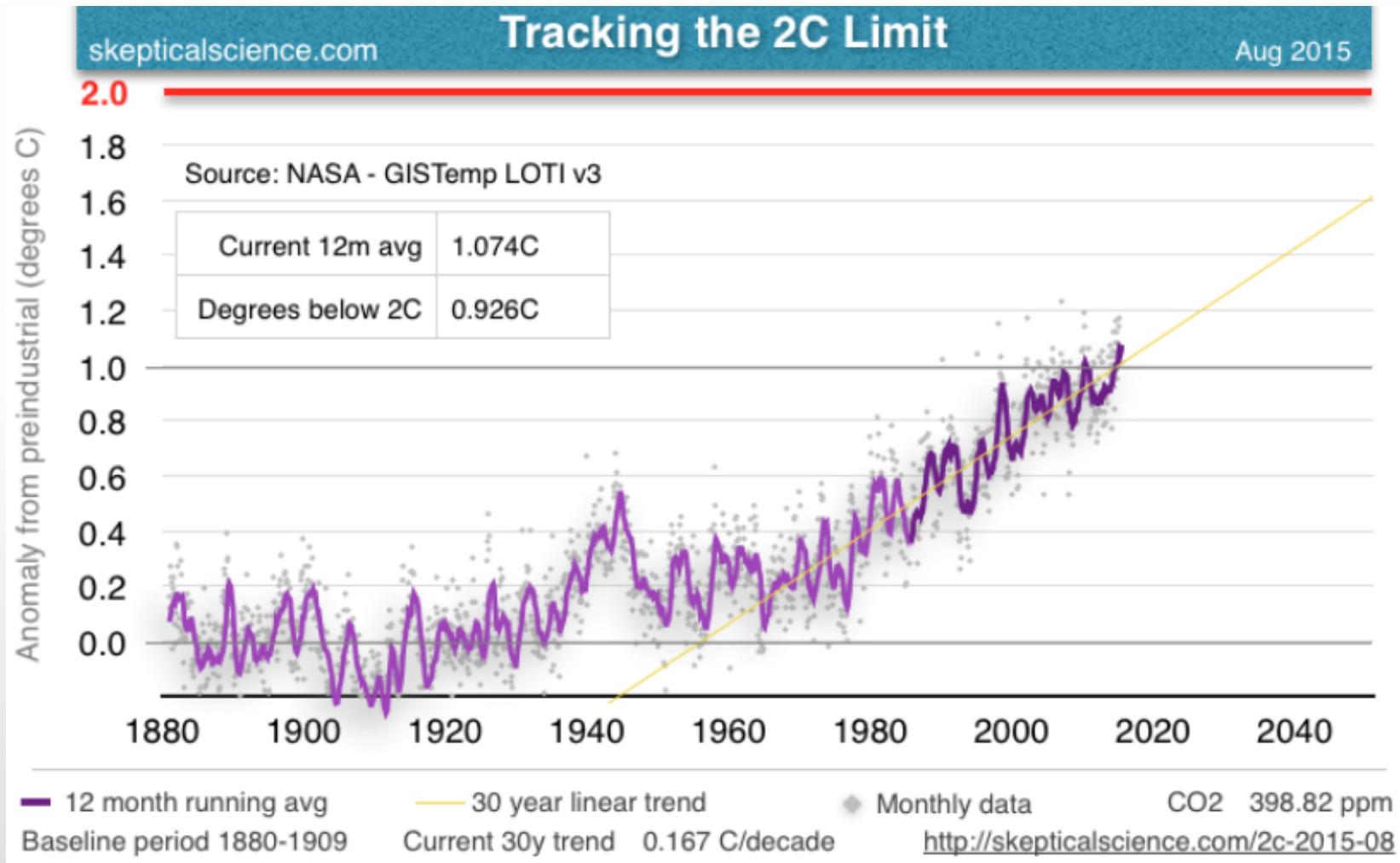
Climate Change: Near Term Effects and Societal Response



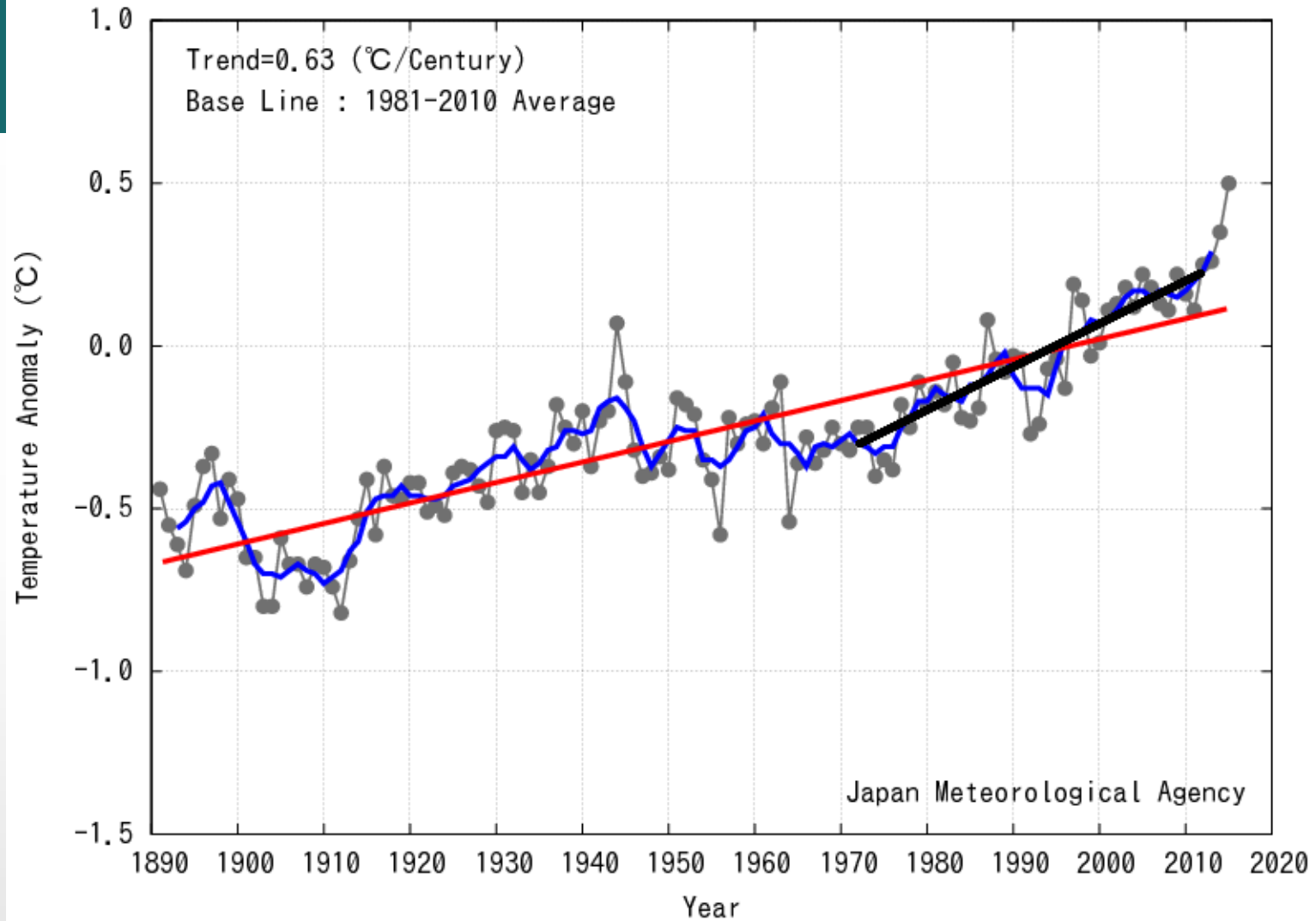
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@Efficiency Nova Scotia Eat & Learn

October 21, 2015

Globally Averaged Temperatures are Rising Above the 30 Year Trend



Monthly Global Average Temperature in September



Anomalies are deviation from baseline (1981-2010 Average).

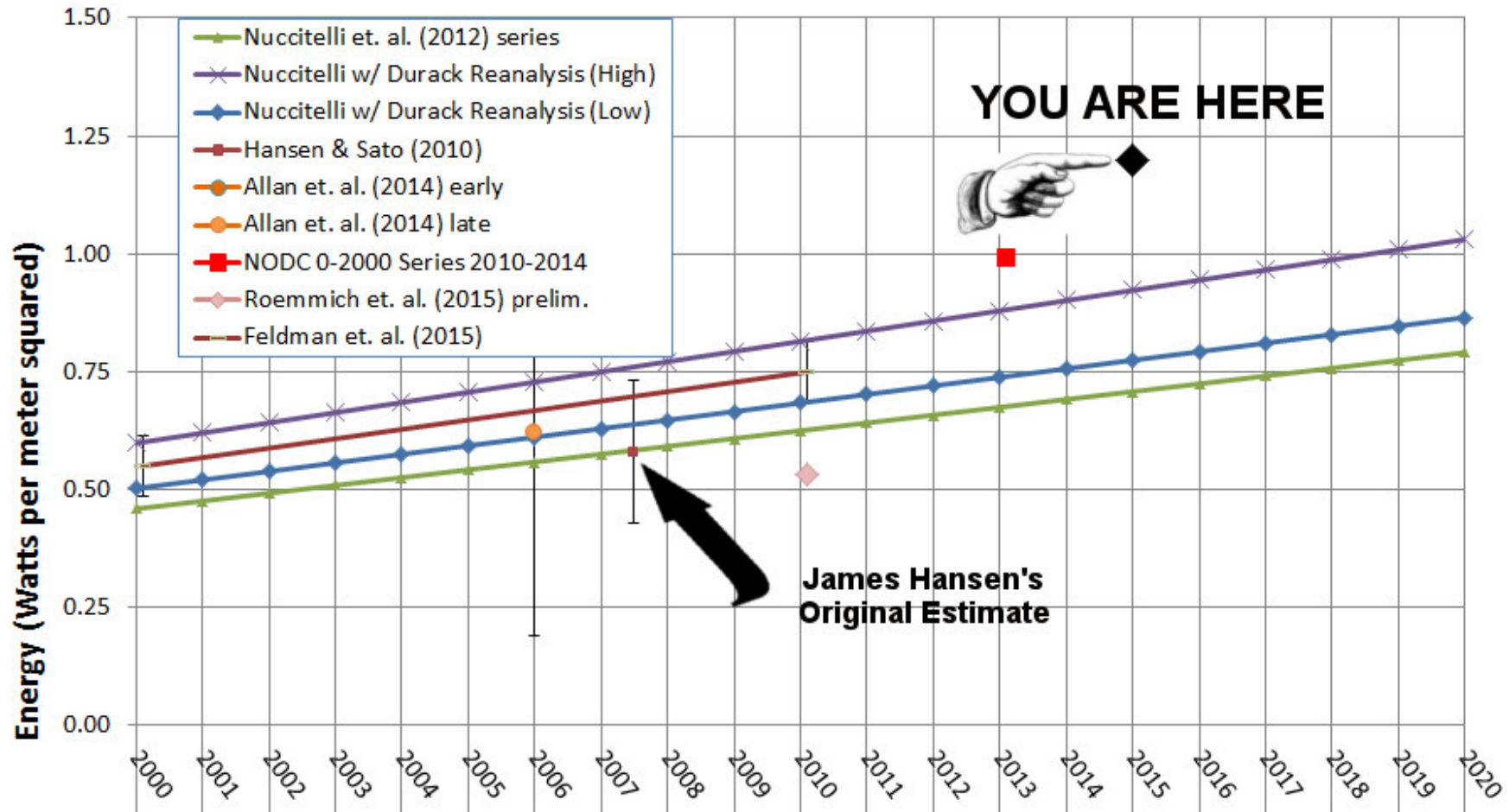
The black thin line indicates surface temperature anomaly of each year.

The blue line indicates their 5-year running mean.

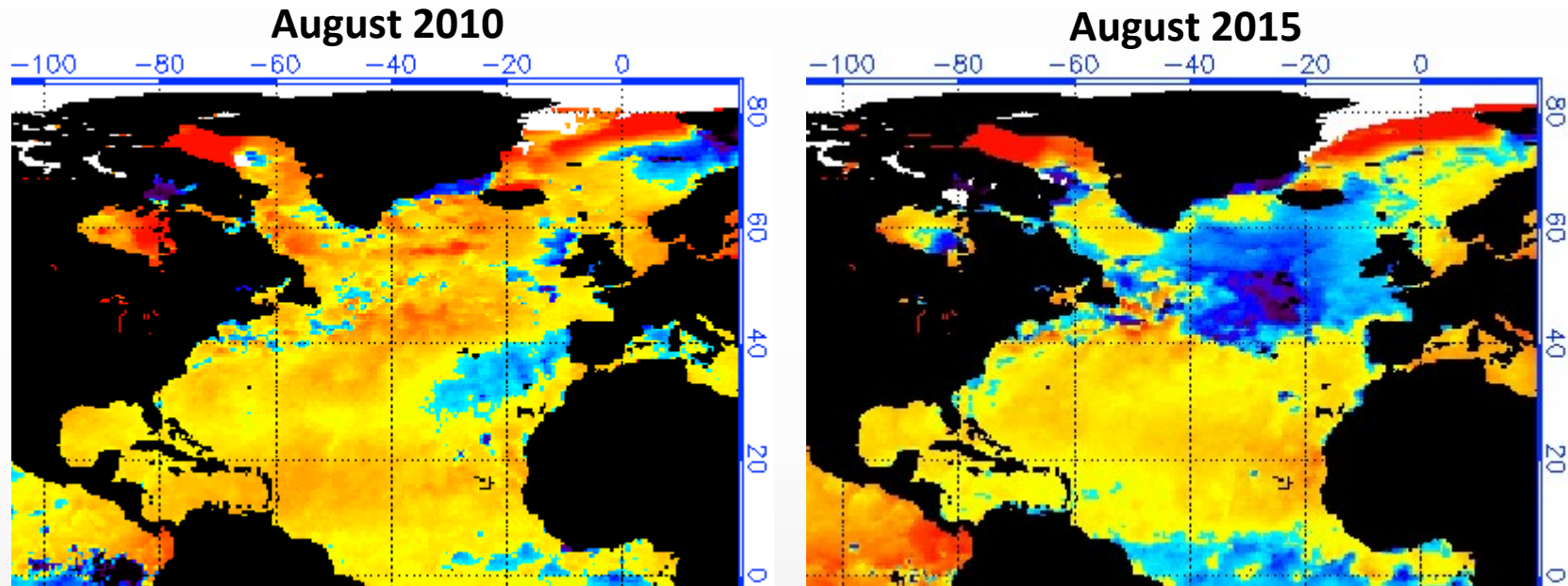
The red line indicates the long-term linear trend.

Earth's Energy Imbalance Has Crossed a Critical Threshold

Net Heat Gain of Planet Earth



Climate Change Effects are More Rapid and Severe than Previous Projections



- Rahmstorf, S., Box, J., Feulner, G., Mann, M., Robinson, A., Rutherford, S., Schaffernicht, E. (2015), **Evidence for an exceptional 20th-Century slowdown in Atlantic Ocean overturning circulation.** Nature Climate Change, DOI:10.1038/nclimate2554.
- Landerer, F., Wiese, D., Bentel, K., Boening, C., Watkins M., (2015), **North Atlantic meridional overturning circulation variations from GRACE ocean bottom pressure anomalies.** Geophysical Research Letters, DOI 10.1002/2015GLO65730

“A slowdown adds to the regional sea-level rise, affecting cities like New York and Boston. Temperature changes in this region can also influence weather systems on both sides of the Atlantic, in North America as well as Europe.”

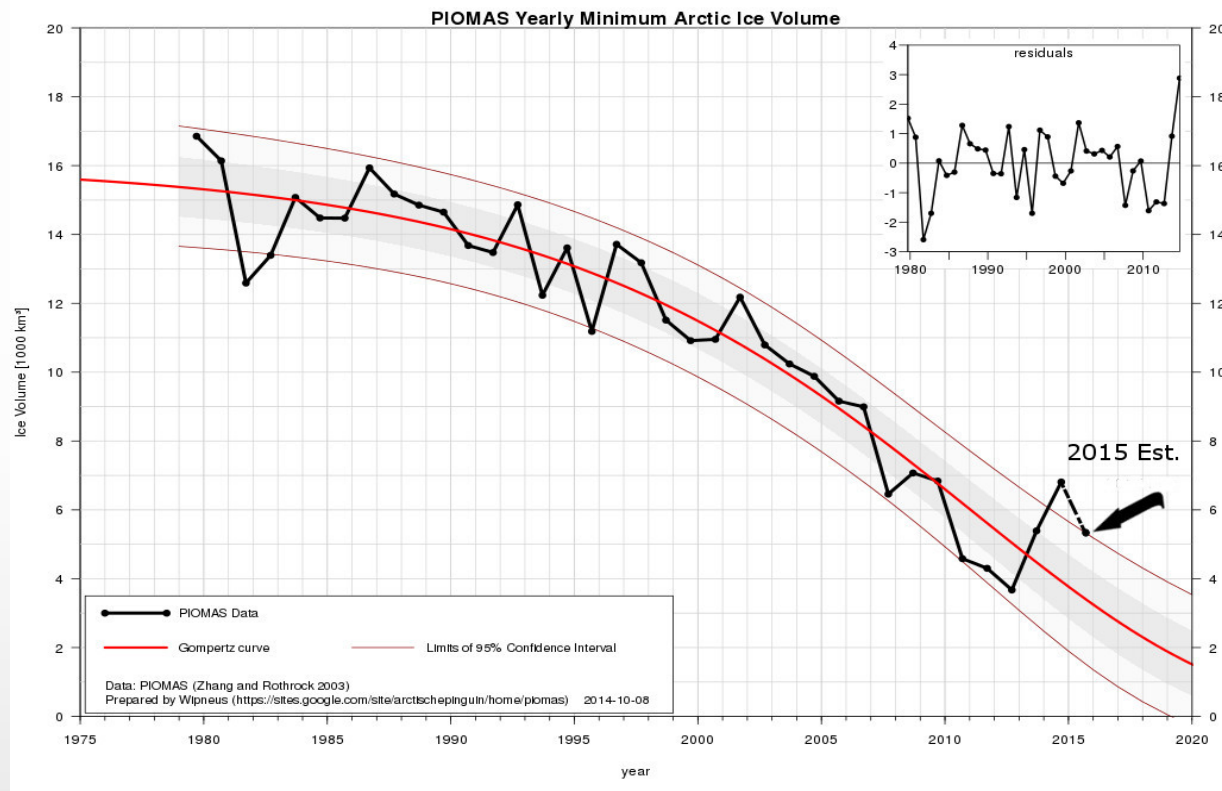
Recent Studies Show Greater Likelihood of Severe Hurricanes in New England



Donnelly, J. P., Hawkes, A. D., Lane, P., MacDonald, D., Shuman, B. N., Toomey, M. R., van Hengstum, P. J. and Woodruff, J. D. (2015), **Climate forcing of unprecedented intense-hurricane activity in the last 2000 years**. *Earth's Future*, 3: 49–65. doi:10.1002/2014EF000274

“We May Need to Begin Planning for a Category 3 Hurricane Landfall Every Decade or so Rather Than Every 100 or 200 Years. The Risk May be Much Greater than We Anticipated.”

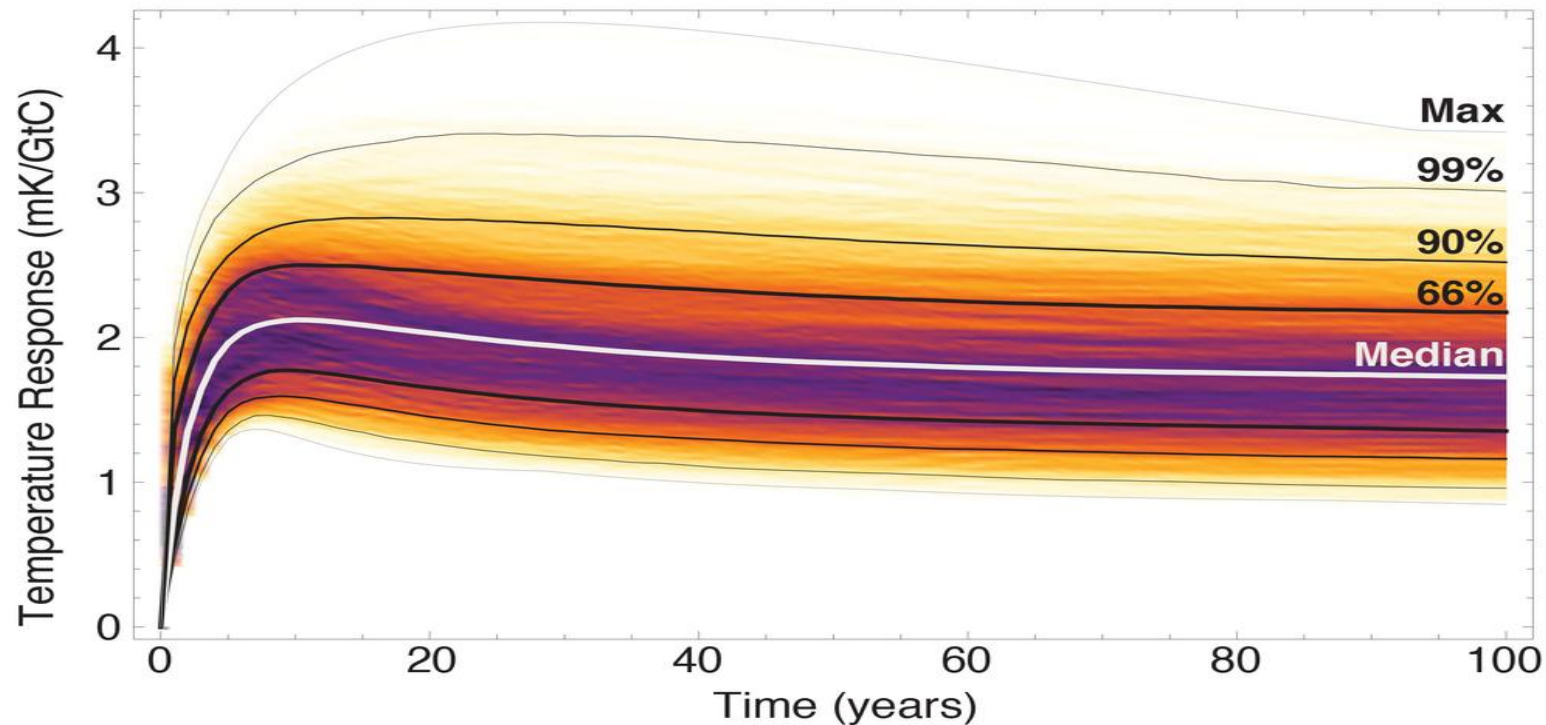
Rapid Reduction of Aerosol Emissions Currently Taking Place



Aerosol impacts on the arctic are amplified, further reductions will lead to increased rates of summer ice loss with effectively ice free Summers likely by 2025.

Najafi, M.R., Zwiers, F.W, Gillett, N.P.: **Attribution of Arctic temperature change to greenhouse-gas and aerosol influences.** Nat. Climate Change., doi: 10.1038/NCLIMATE2524, 2015

Significant Near-term Warming Will Result from Reducing Fossil Fuel Consumption



Ricke & Caldeira. *Environ. Res. Lett.* (2014)

Aerosol emission reductions resulting from transitioning away from fossil fuels will generate as much additional warming by 2030 as is currently being experienced globally.

Pietikäinen, J.-P., Kupiainen, K., Klimont, Z., Makkonen, R., Korhonen, H., Karinkanta, R., Hyvärinen, A.-P., Karvosenoja, N., Laaksonen, A., Lihavainen, H., and Kerminen, V.-M.: **Impacts of emission reductions on aerosol radiative effects**, *Atmos. Chem. Phys.*, 15, 5501-5519, doi:10.5194/acp-15-5501-2015, 2015.

Likely Near-Term Impacts from Rapid Global Warming

- Continued increase in frequency of extreme heatwaves, droughts and flooding events. **(very likely)**
- Continued collapse of Gulf Stream current resulting in regional weather pattern shifts and sea level rise on the U.S. East Coast. **(likely)**
- Equivalent Arctic ice-free conditions by mid-September 2025, with associated extreme weather pattern shifts. **(extremely likely)**
- Unprecedented category 3 or 4 hurricane landfalls in U.S. Northeast, resulting in catastrophic flooding and coastal erosion. **(likely)**
- Rapidly increasing globally averaged temperatures as a result of global aerosol emissions reductions, El Nino Oscillation and locked-in warming from previous CO2 emissions. **(certain)**

**Within this New Climate Regime that We Are Entering,
What Will the Likely Response be to These Impacts?**

Current and Projected Legislative Mitigation Goals are Inadequate

- Global Intended Nationally Determined Contribution (INDC) targets submitted to the UN COP21 project a level of global annual emission of 57-59 billion tons of CO₂ equivalent GHGs by 2030. This is far short of the IPCC stated target of 36 billion tons required to produce a 50-66% chance of remaining below 2°C of warming.
- Growing body of evidence suggests that the 2°C limit is too high and will result in catastrophic and irreversible impacts to critical ecosystems and to society. (e.g. Arctic region, tropic and boreal forest systems, regional droughts and wildfires. “Threat multiplier” effect of resource-driven conflicts. . .)
- Growing indications that Earth system feedbacks are responding more rapidly than models entail. (e.g. carbon cycle feedbacks, frozen soils and reduction in Dimethyl Sulfide Emissions from oceanic and terrestrial sources. . .)

As Undeniable and Catastrophic Climate Impacts Continue to Increase, Public Pressure Will Necessitate a Policy of National Mobilization.

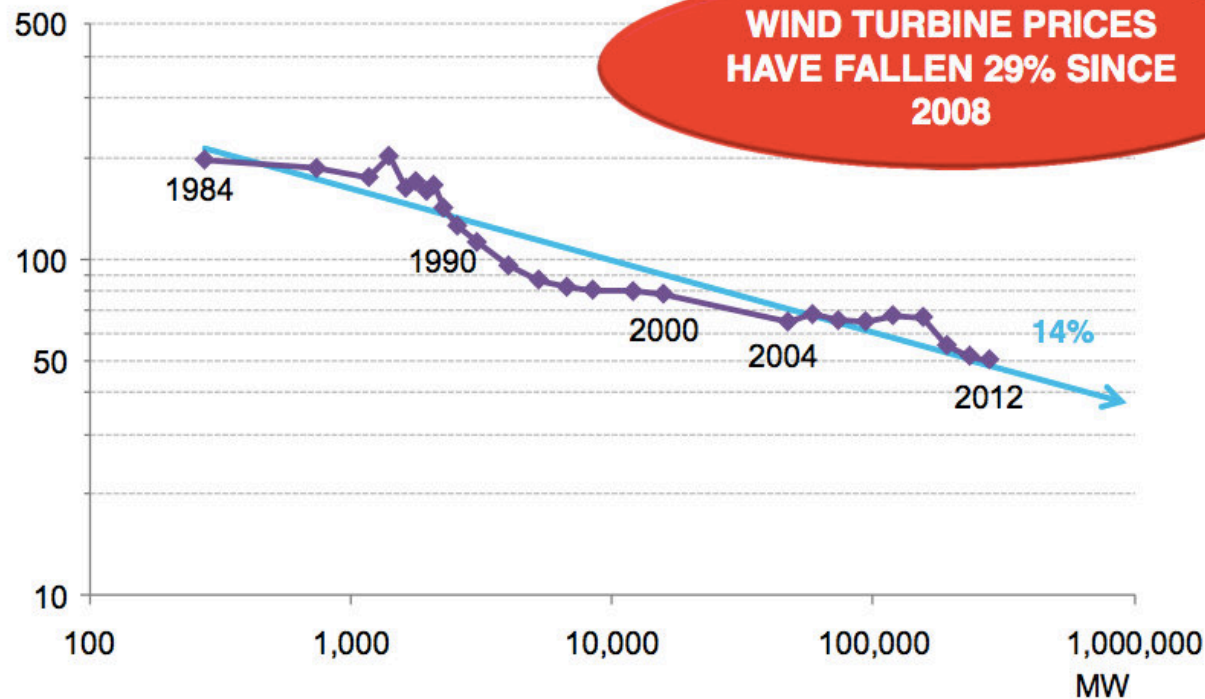
Necessary De-Carbonization of the National Energy Mix

- U.S. Zero Carbon Emissions by 2050
- Nova Scotia Must Lead!
- Interim Target of 50% Carbon Emissions Reduction by 2030 (Only 15 Years Away!)

This Aggressive Policy of Economic Transformation Will be Demanded by the Public to Ensure National Security and Social Stability.

Macro and Mirco Wind Becomes Cost Competetive

AVERAGE LEVELISED COST OF ONSHORE WIND, 1984-2012 (€/MWH)

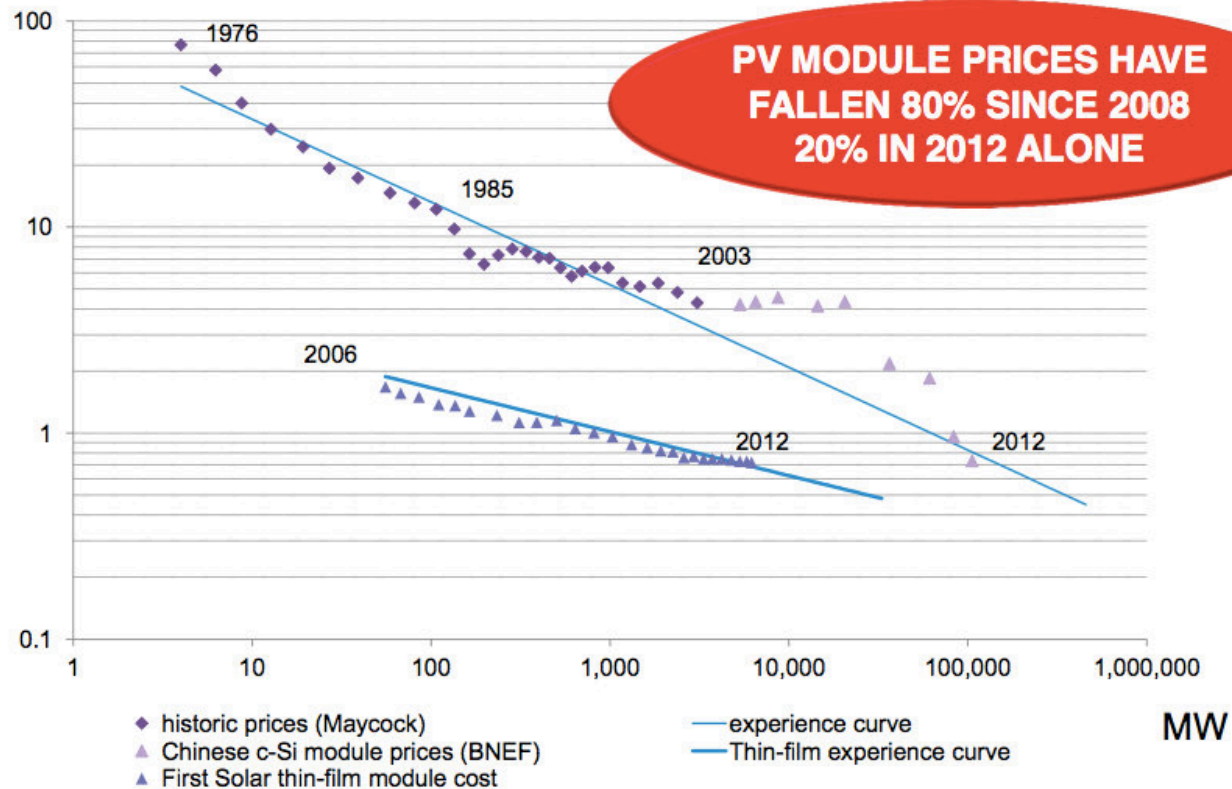


Note: Learning curve (blue line) is least square regression: $R^2 = 0.88$ and 14% learning rate.

Source: Bloomberg New Energy Finance, ExTool

Solar PV Becomes Cost Competitive

PV EXPERIENCE CURVE, 1976-2012
2012 \$/W

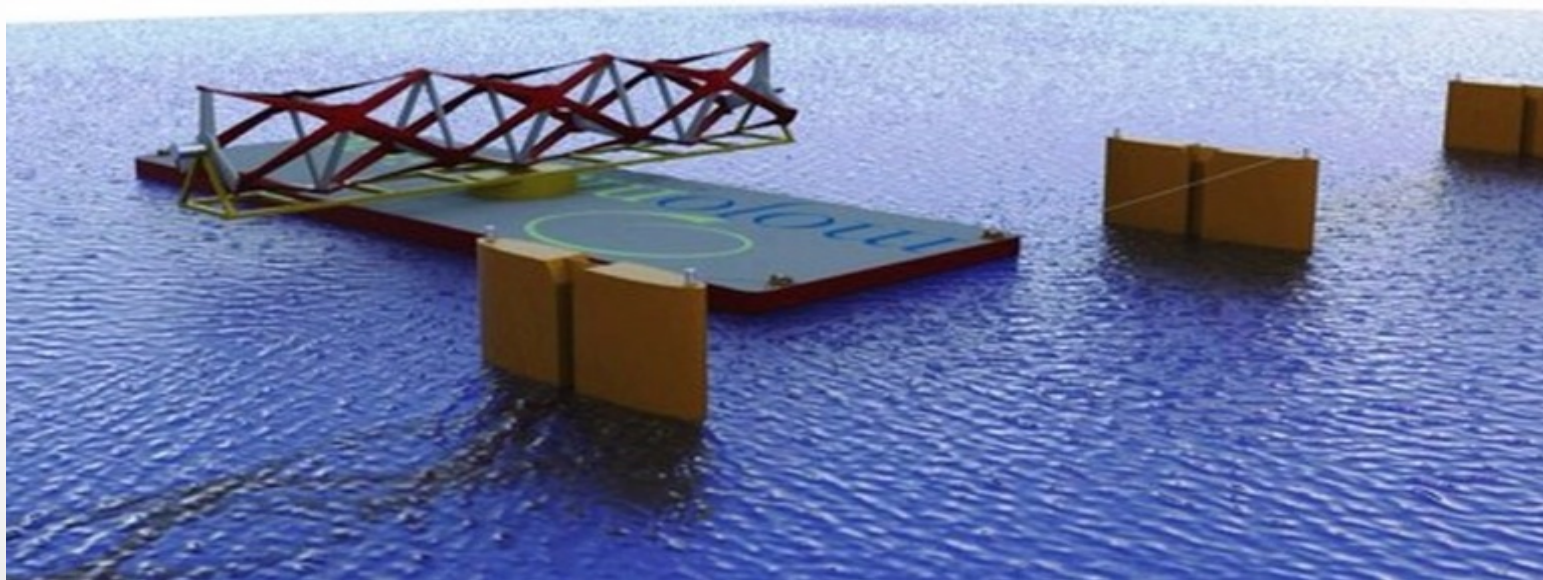


Note: Prices inflation indexed to US PPI.

Source: Paul Maycock, Bloomberg New Energy Finance

New Developments in Low-Flow Tidal Power

Transverse Horizontal Axis Water Turbine - THAWT



Oxford University's 30 MW Bristol Channel generation system currently being built See: **"Kepler Energy Reveals Plans for Tidal Energy Scheme in Bristol Channel"** July 5, 2015, Gizmag.

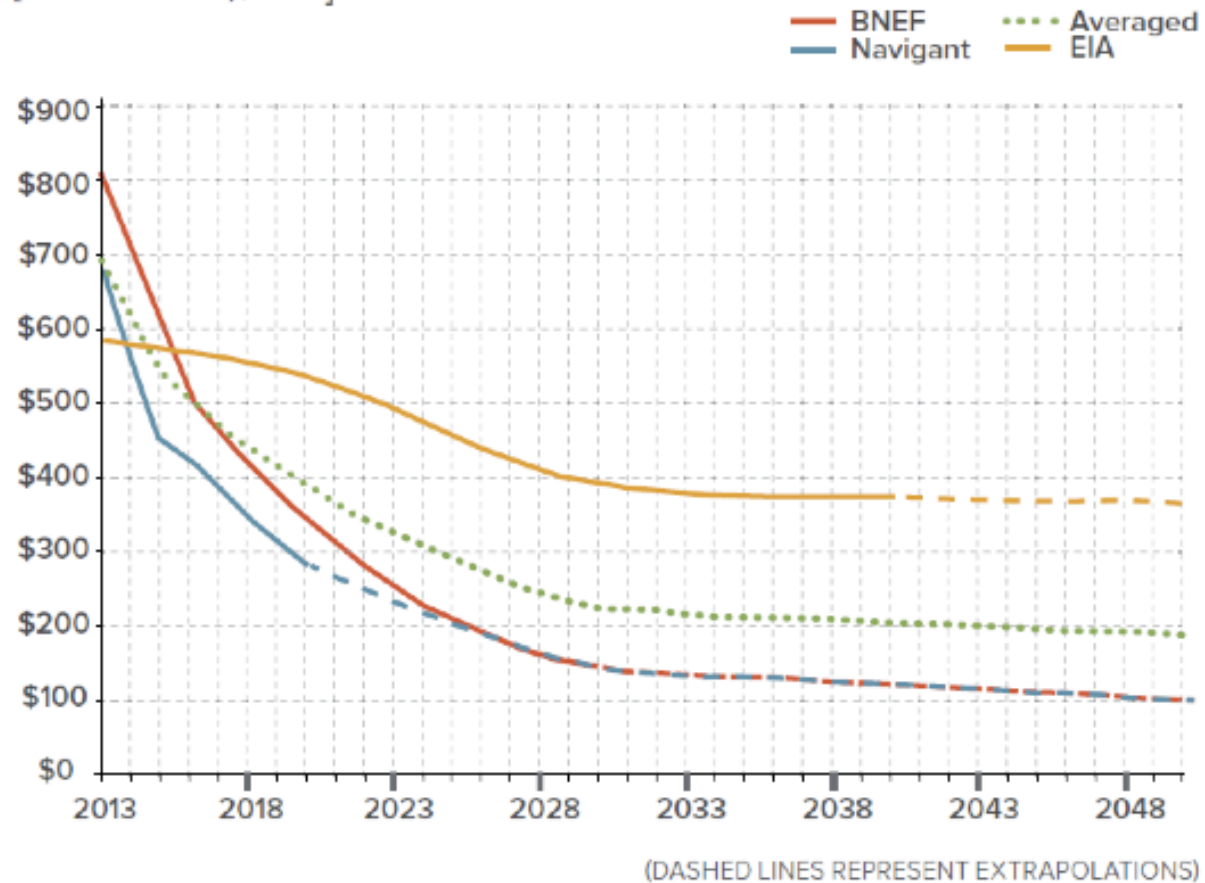
Energy Storage Potential Growing

- Elon Musk announces 1,000 Km capacity electric vehicle by 2017 – impossible using current battery technology
- 10 MW “hybrid building” project in southern California partnership with Tesla and Irvine Real Estate
- Battery Storage Market set to increase 10-fold in 3 years to 2,400 MW – Navigant Consulting
- New technology developments driving price per kWh far below industry projections

Li-Ion Batteries will be dinosaurs for Grid-Storage in 5 years

Figure 41: Blended Battery Price Projections

BATTERY PRICE PROJECTIONS [Y-AXIS 2012\$/kWh]



Source: Rocky Mountain Institute

Biochar as Ag Amendment + Syngas Electric Peak Generation

- Small Scale biochar + Syngas generation from forestry and agricultural waste streams produce approximately 350,000 tonnes for 60MW of generation potential
- See: *Forest Biomass Energy Report II: Potential for Small-Scale, CommunityBased Biomass Energy Projects in Nova Scotia Dale Prest, Dalhousie University*
- With Moderate Carbon Tax policy and Feed-in Tariff combined with subsidy for small-scale agricultural amendment becomes a potential carbon mitigation and economic development strategy.

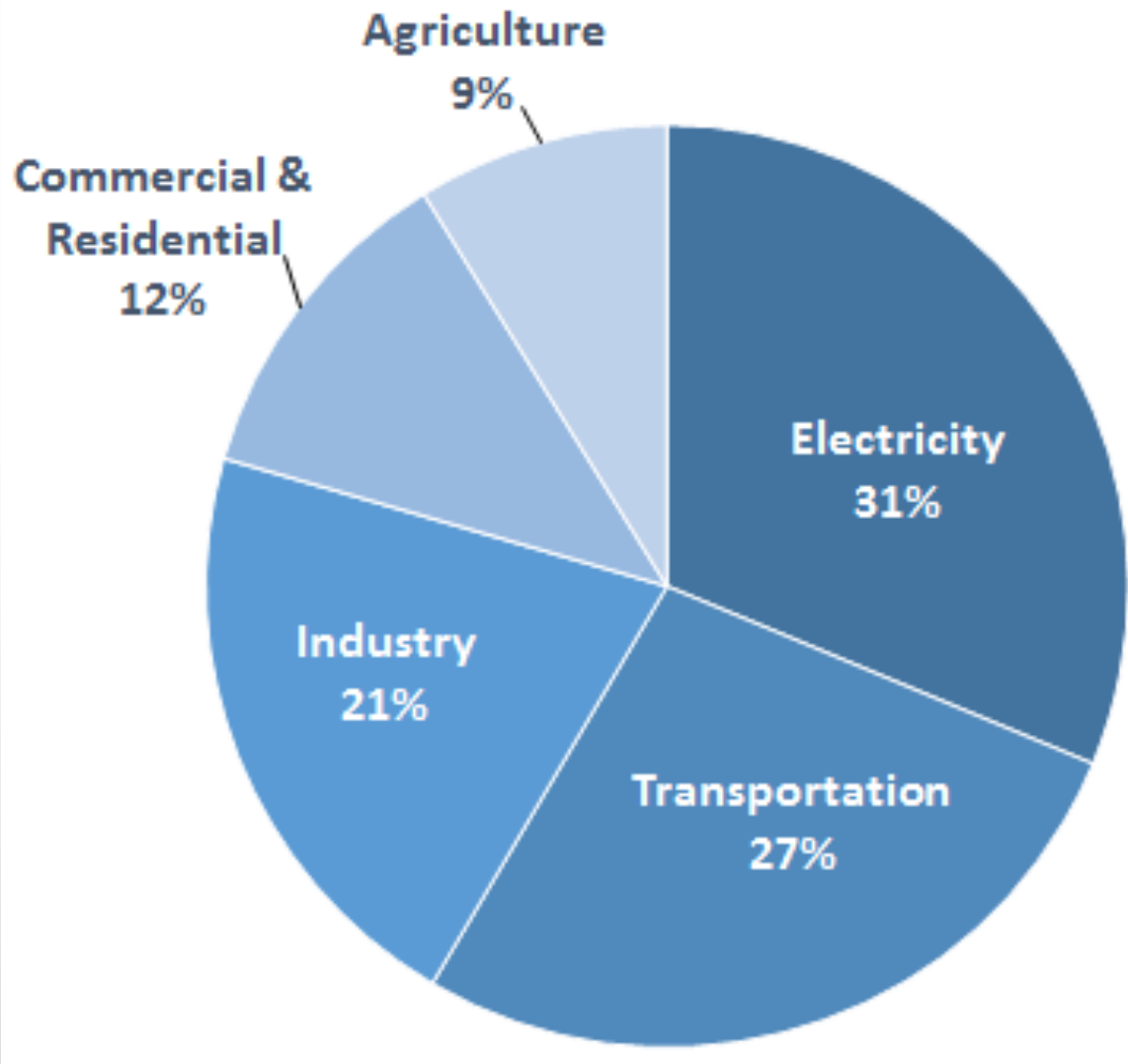
Societal Mobilization Response

- **Creation of the Federal Climate Mitigation & Adaptation Authority**
- **Implementation of Regional Manufacturing Centers with Localized Zero Emissions Energy Supplies**
 - Manufacture and implementation of heavily subsidized renewable energy generation infrastructure – **(comparable to the rural electrification project)**
 - Manufacture and implementation of regional and interstate light-rail buildout – **(comparable to the national highways project)**
 - Manufacture and implementation of regional feedstock development, transportation and pyrolysis systems for biochar production and distribution for regenerative distributed small-scale agriculture use – **(comparable to the Victory Gardens Project)**

Societal Mobilization Response

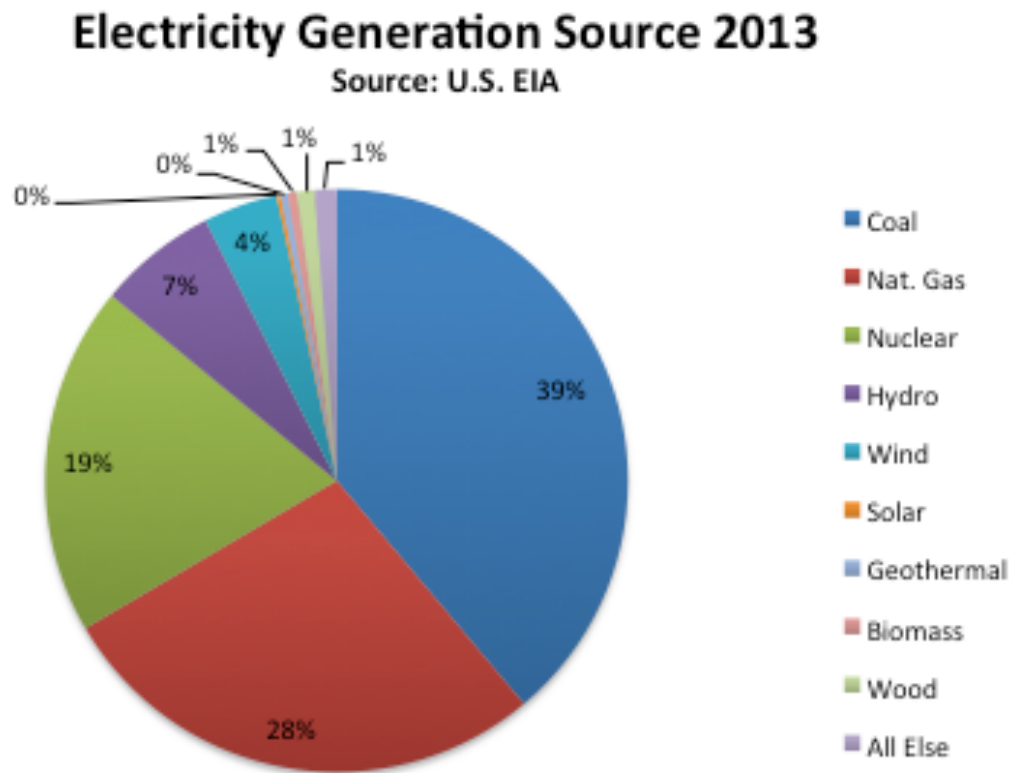
- Implementation of a Social Cost of Carbon levy on all economic activity – (Carbon Tax)
- Nationwide building envelope and energy efficiency retrofit program
- Manufacture of net-zero housing stock in preparation for climate induced migrations away from southwest desert states
- Manufacture of resiliency and adaptation infrastructure (e.g. cooling centers, flood controls, hurricane surge and sea level rise controls)

U.S. GHG Emissions by Sector



Source: US EPA

U.S. Electricity Generation



- Fossil fuel combustion accounts for about 98% of GHG emissions in the electricity sector.
- While coal represents about 39% of generation, it accounts for about 77% of GHG (CO₂e) emissions.
- Total renewables represented about 13% of generation in 2013.

U.S. Electric Generation - 2013

Source	Capacity (GW)	Generation (GWH)
Coal	303	1,581,115
Natural Gas	425	1,124,836
Nuclear	99	789,016
Hydro	79	268,565
Wind	60	167,840
Solar	6.6	9,036
Geothermal	2.6	15,775
Biomass	5.0	20,830
Wood/derivatives	8.4	40,028
All else	70	48,923
Total	1,060	4,065,964

Estimated U.S. Renewables Technical Potential

Technology	Capacity (GW)	Generation (GWh)
Urban Utility-Scale PV	1,200	2,200,000
Rural Utility-Scale PV	153,000	280,600,000
Rooftop PV	664	800,000
Concentrating Solar	38,000	116,100,000
Onshore Wind	11,000	32,700,000
Offshore Wind	4,200	17,000,000
Biopower	62	500,000
Hydrothermal	38	300,000
Enhanced Geothermal	4,000	31,300,000
Hydro	60	300,000
Total	212,224	481,800,000

Source: U.S. Renewable Energy Technical Potential, NREL, July 2012.

The Nuclear Dilemma

- 7-10 years of renewable operations required to offset embedded emissions required for manufacturing, distribution, and installation of technologies under current fuel mix.

Source: N. P. Myhrvold, K. Caldeira, *Greenhouse gases, climate change and the transition from coal to low-carbon electricity*, Environ. Res. Lett. 7 (2012) 014019 (8pp), doi:10.1088/1748-9326/7/1/014019, 2012

- To produce the necessary transformation of the U.S. energy mix to a carbon-free system, a massive buildout of immediately available carbon-free energy will be required.
- Nuclear power will be the most likely source of this energy.
- Regional manufacturing centers will require approximately 2.7 GW of new generation capacity per location (12 locations distributed nationally).

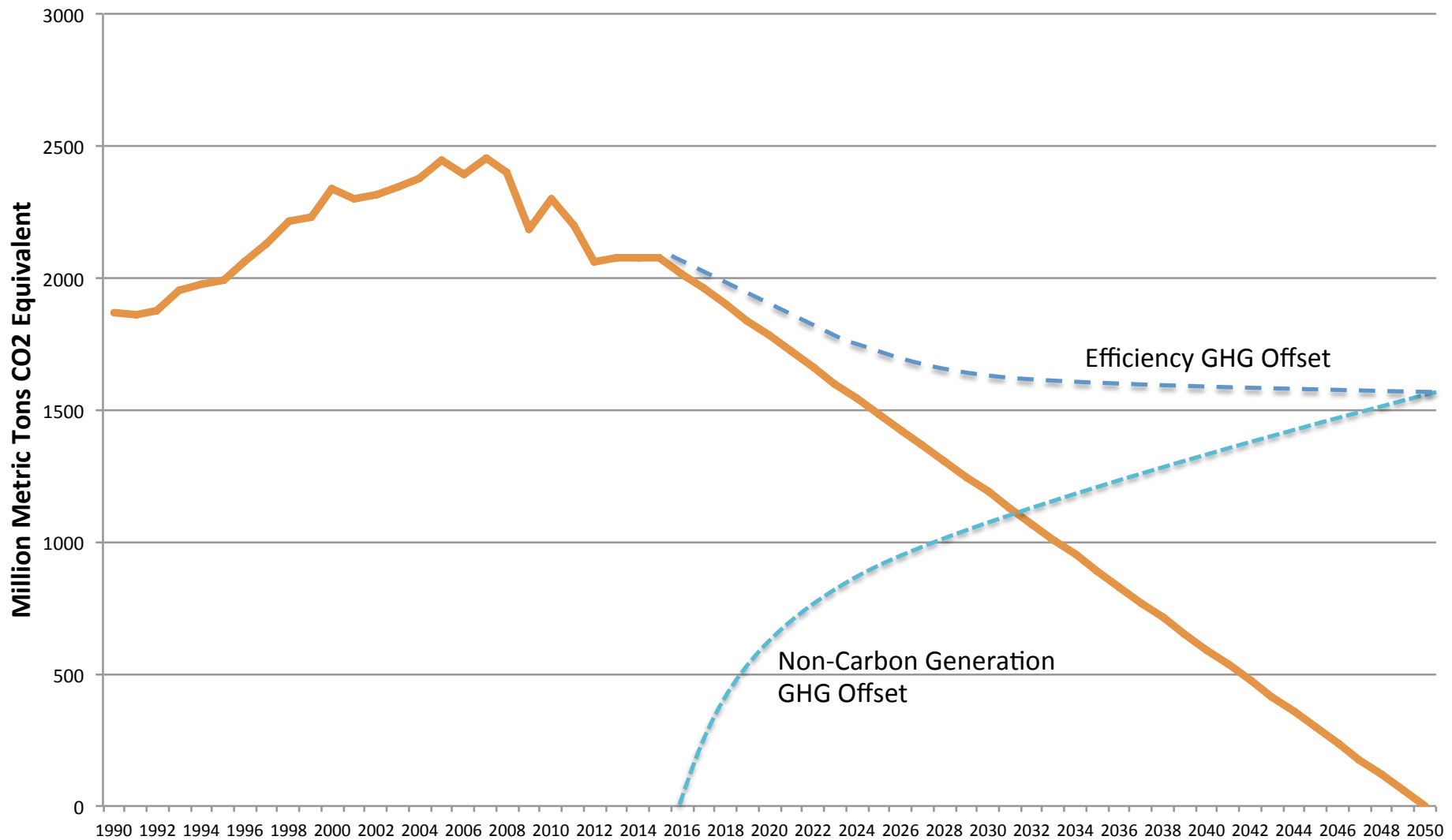
100% Renewables by 2050

Transition to 100% wind, water, and solar (WWS) for all purposes
(electricity, transportation, heating/cooling, industry)



Source: Mark Jacobson PhD, The Solutions Project, Stanford University, 2015.

U.S. Economic Transition to Carbon-free Electricity Sector



Transitional and Long-term Shift in the IOU Business Model

- Reaching 50% national emissions reductions by 2030 will require the installation of approximately 50,000 MW (per year) of carbon-free source generation over the next 15 years!
 - Dependent upon the pace of electrification of transportation.
- Forced early retirement of current generation capacity – shift to distributed energy and load shifting capability.
 - Stranded asset cost recovery mechanisms will likely be tied to carbon reduction and efficiency targets.

Transitional and Long-term Shift in the IOU Business Model

- Electrification of industrial, transportation, construction and agriculture sectors will drive a 40% increase in electricity demand over a period of 10 years after mobilization initiation.
- Aging nuclear power generation facilities will require new zero carbon generation production.
- Industry long-term shift away from single source generation into efficiency and distributed energy material delivery.

ERA 2 – Mobilization – Beyond the Utility of the Future

WWII Level Mobilization

- During World War II, in the United States, a considerable number of consumer's goods (mainly foods) were **rationed**, and a very large number of producer's goods and materials were subject, **(through the allocation of the entire supply to specified uses)**, to equivalent control. – J.K. Galbraith, *A Theory of Price Control*. Cambridge: Harvard University Press, 1952, P. 10.
- During the early months of price control, a strenuous effort was made to gain acceptance for the principle of using **subsidies to offset higher “marginal” costs** in increasing-cost industries. -- Galbraith, P. 23
- However, most industrial expansion during the war was at a **constant or decreasing cost**. -- Galbraith, P. 23.

ERA 2 – Mobilization – Beyond the Utility of the Future

Mobilization Works

- **Mobilization:** Rationing, direct allocation of raw materials and producer goods and subsidies to offset high marginal costs, fusion of Government/ Industry planning and coordination.
 - **In a survival situation, mobilization works.** One reason is that most key markets operate imperfectly in normal times. They actually work through deals and interorganizational arrangements – textbook consumer choice has little to do with it. The key necessary markets are comparatively easy to direct and coordinate through central administration.
 - The experience of industrial direction in WWII was that. Most industrial expansion during the war was at a **constant or decreasing cost.** -- Galbraith, P. 23.

U.S. WWII Mobilization Cost \$26 Trillion in Current Inflation-Adjusted Dollars!

Impacts on the IDSM Industry

- A large expansion of work.
- Meaningful employment in one of the key industries that will be important during the difficult times of climate adjustment – stable and enhanced work opportunities.
- Need to bridge out from DSM to IDSM to DER's and Microgrids.

Impacts on the IDSM Industry

- Microgrids, which can island and buy and sell – require an EM&V protocol with a much larger scope and set of methods than those directly relevant to the DSM piece.
- Need to develop skills and training in climate mitigation and climate adaptation.
- Energy will need to fit inside environment – there will not be two areas.
- Need to bridge out to form alliances with cities and other levels of government

QUESTIONS?

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