NEW SUBSIDIES FOR OLD REACTORS

NO BRIDGE TO CLEAN ENERGY

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Nuclear Subsidies & Bailouts
Costs, Impacts, Responses
April 11, 2017

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– For a Nuclear-Free, Carbon-Free World –

Nuclear Power Seeking New Subsidies

Industry Campaign

- Started in 2014
- Front Groups - Nuclear Matters, Environmental Progress, etc.
- State and Federal Strategies

State-Level Subsidies

- Adopted: New York (Aug. 2016) and Illinois (Dec. 2016)
    - 6 reactors, $10 billion
- Proposed: Connecticut, Ohio, Pennsylvania, New Jersey
- Expected: Maryland, Texas, Michigan ...

Federal Proposals

- Dept. of Energy - 2016 Summit and two task force reports
- FERC - subsidies, incentives

We've Seen This Before

Deregulation = Nuclear Bailout 1.0

Stranded Cost Bailout

- 1997: $76 billion in bad debts
    - $130 billion (2016)

Industry Cost-Cutting

- Ownership Consolidation
- Workforce Reductions
- Property Tax Reductions
- Decom Fund Transfers

Safety Rollbacks

- Generic Relicensing
- Power Uprates
- "Risk-Informed Regulation"
- Fewer Refueling and Maintenance Outages

No Reactor Closures for 14.5 Years

- **1990s: Wave of closures**
    - 9 reactors in eight years
    - "Nuclear-Free New England"
- **Safety Enforcement/Campaigns**
    - Systemic Mismanagement
    - Whistleblowers
    - Aging: Major Components

Reactor Closures by Decade

1960s	2
1970s	8 (prototypes)
1980s	4
1990s	9
2000s	**0**
2010s	6 (+3 planned, 5 possible)
2020s	8 planned (more possible)

What About *New* Nuclear?

Unrealistic and Irresponsible

- Too Dirty ...
- Too Dangerous ...
- Too Expensive ...
- Too Slow ...

Nuclear Renaissance = Nuclear Nosedive

- 32 reactors ordered ↘️ 4 under construction

Most Major Firms Going Bankrupt

- Areva + Westinghouse
- Who's Next? EdF ... Rosatom ... GE

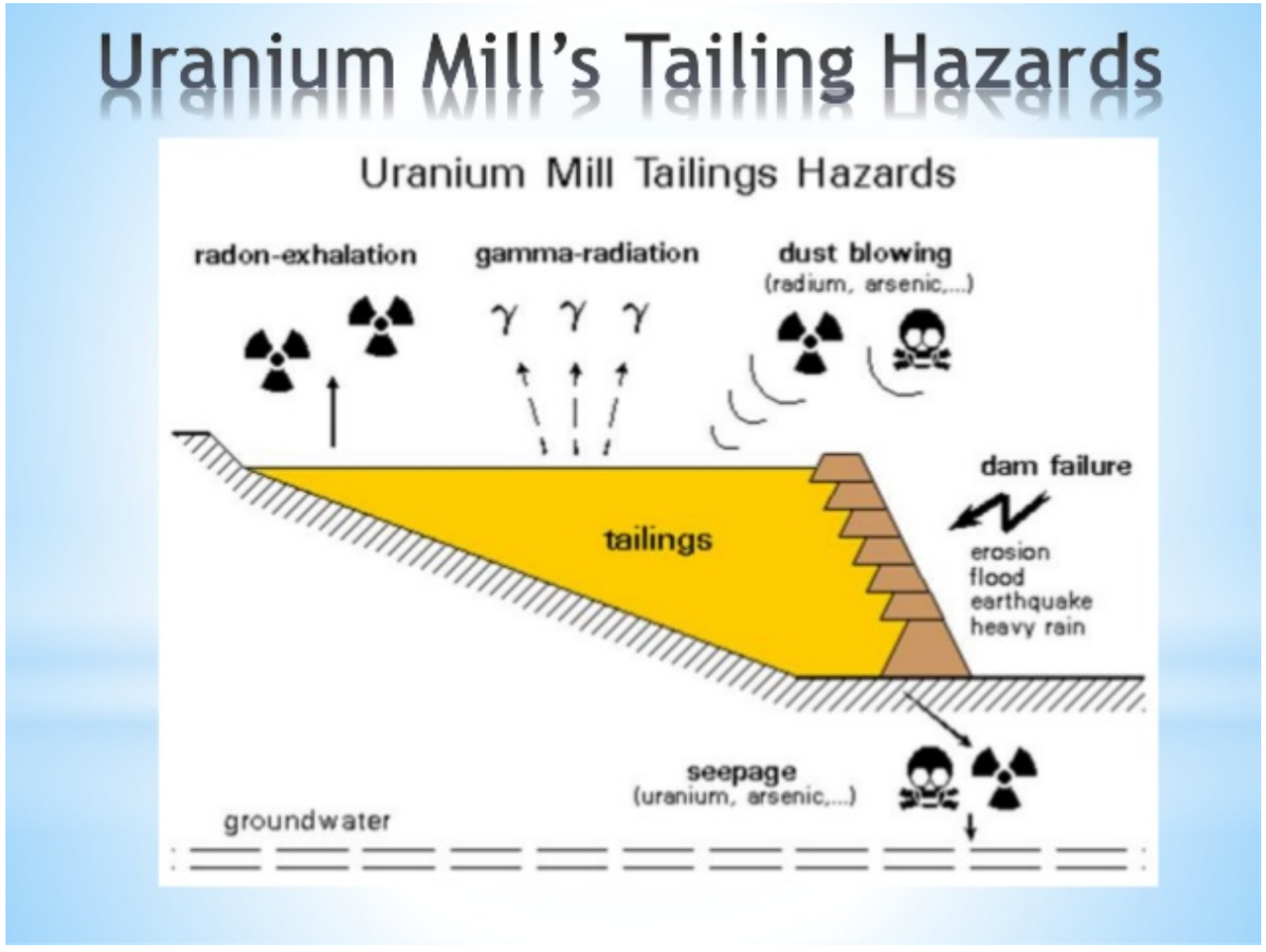
#NuclearIsDirty

Nuclear Power is *NOT* Clean Energy

- Environmental Justice
- Radioactive Waste
- Routine Releases and Leaks
- Nuclear Disasters
- Water Consumption and Ecosystems
- Carbon Footprint

Nuclear Fuel Chain

- **Uranium Mining and Milling**
  - 25,000 lbs. waste per 1 lb. nuclear fuel
  - 15,000 abandoned uranium mines
  - First Nations targeted here and worldwide
- **Depleted Uranium**
  - 7 lbs. per 1 lb. enriched uranium
- **Irradiated ("Spent") Fuel**
  - 2,200 tons every year (22 tons per reactor)
  - 1 million X more radioactive ... flammable
  - Hazardous for 1 million years



New Reactors: Too Expensive, Too Slow

Four Reactors in Construction

- 4 years behind schedule
- 50% over budget
    - **Vogtle 3 & 4:** $20.8 billion from $14.1 billion
    - **Summer 2 & 3:** $14 billion from $9.8 billion

Heavily subsidized

- $8 billion Loan Guarantees + "CWIP" Financing
- 10-year tax credit ($18/MWh)

Westinghouse Bankruptcy

- Reactors may be cancelled

Why New Subsidies for Old Nukes?

Aging Reactors, Worsening Economics

- Maintenance Costs Rising
- Energy Demand Decreasing
- Electricity Prices Decreasing
- Solar + Wind + Efficiency + Storage + SmartTech

Reactors Closing

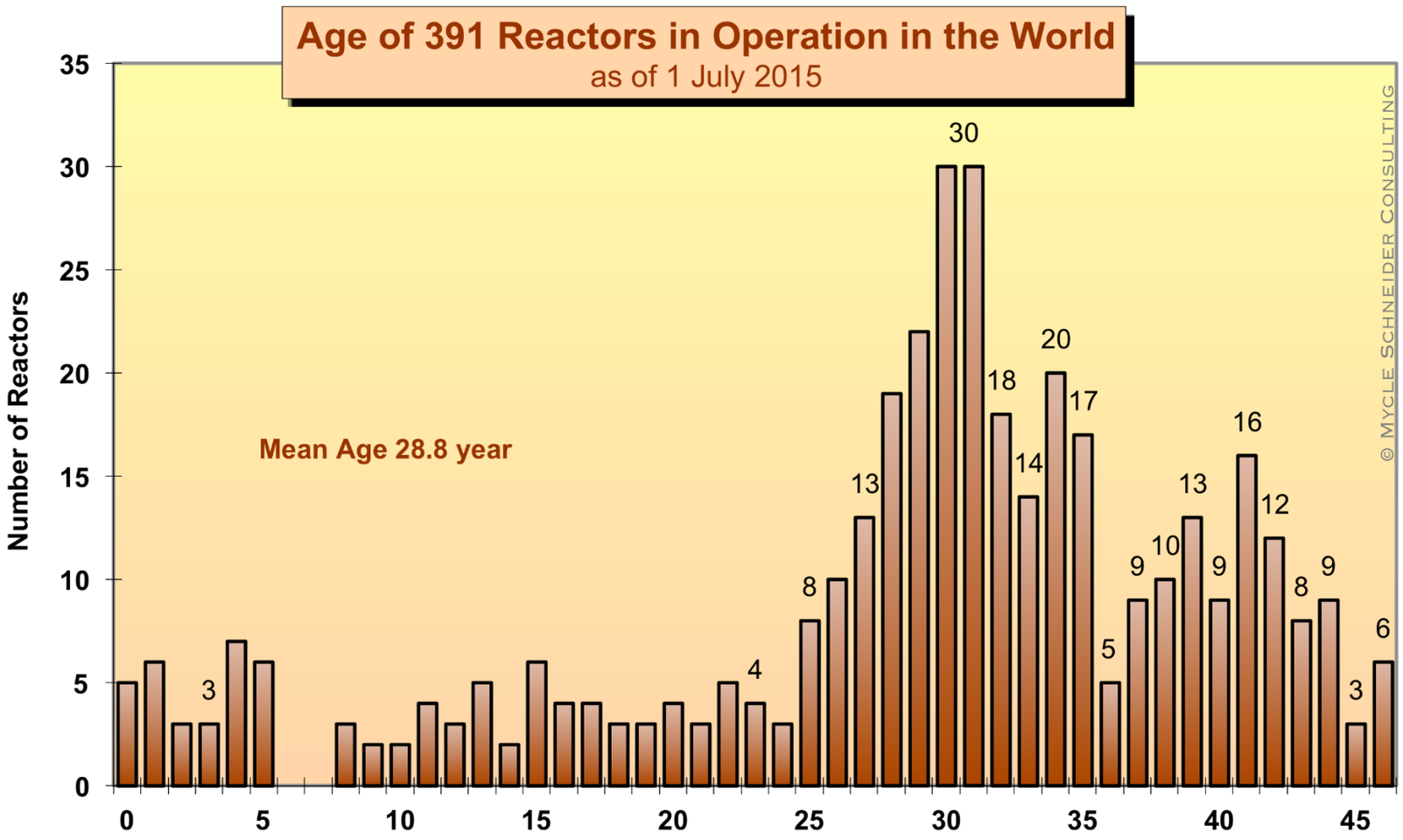
- 2013: Five reactor closures
- 2015-17: Twelve closures announced, more possible
    - **5 closures *REVERSED* by bailouts in 2016 (NY, IL)**

Nuclear Renaissance Failed

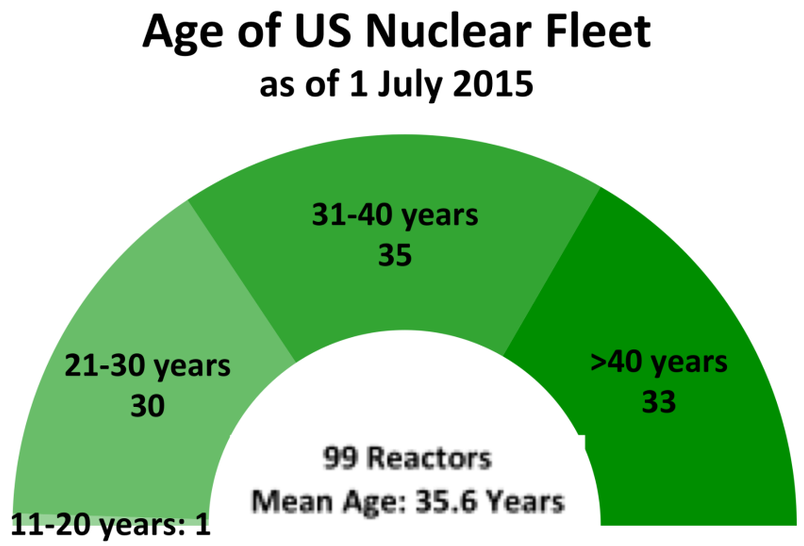
- Propping up old reactors = Industrial life support

U.S. Reactors Older than Global Average

Figure 11: Age Distribution of Operating Nuclear Power Reactors



Sources: IAEA-PRIS, MSC, 2015



Sources: IAEA-PRIS, MSC, June 2015.

Worsening Economics

Operating Costs Rising

- Up 50%+ over 10 yrs. (2002-12)
- 4.5% per year

Aging Out

- Average = 36 years
- 35% over 40 years

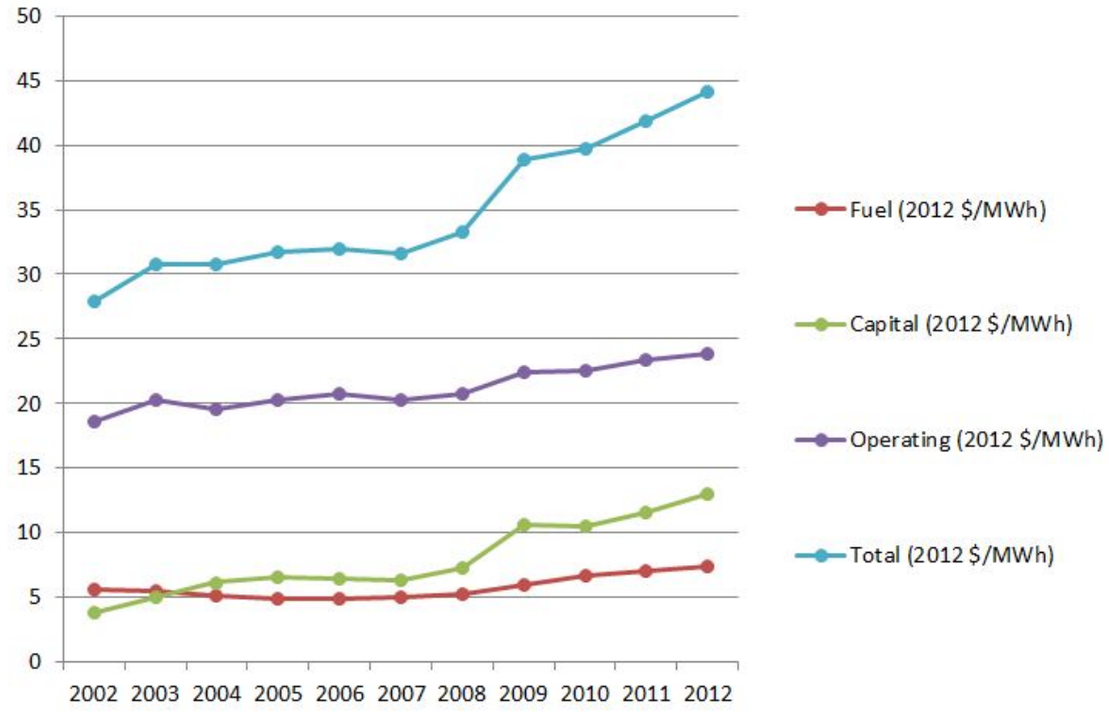
Reactor Characteristics

- Smaller + Single-Reactor + Older
- Average Reactor = 1,080 MW
  - Ft. Calhoun = 480 MW

Nuclear Can't Compete

- Texas: 18 GW wind -- 4.4 GW nuclear
- Midwest: 2.0¢/kWh wind vs. 4.4¢ nuclear

Average Reactor Operating Costs ($/MWh - 2012 dollars)



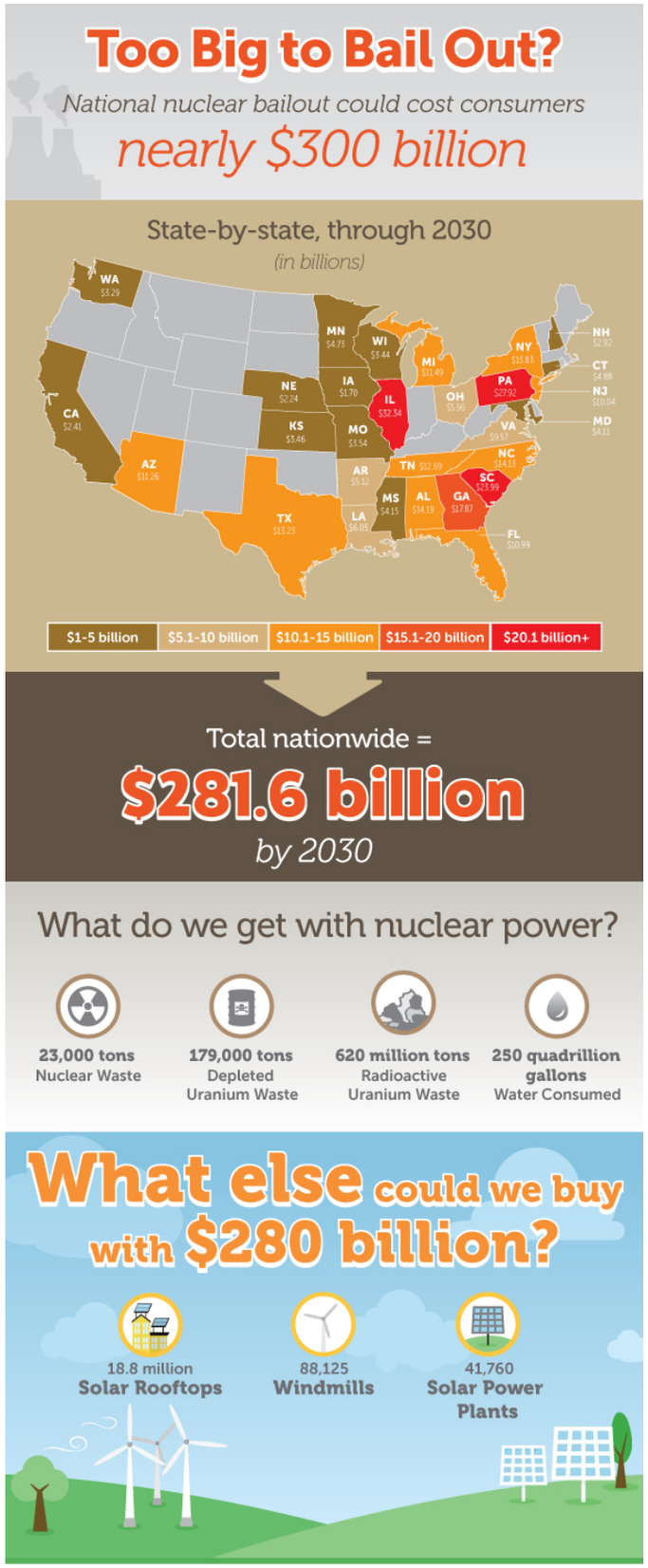
Not Too Big to FAIL ...
Too Big to BAIL OUT!

NIRS Report

- Subsidies for *Existing* Reactors
- Tracks State Proposals and Trends

National and State Costs

- Based on New York-Illinois
- $282 Billion for all 103 reactors by 2030
- $160 Billion for Unprofitable Reactors



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Subsidy Models

Operating Cost Subsidies

- Utility buys power at subsidized price
- "Break-even" subsidy
    - Projected Operating Costs ***minus*** Projected Revenue
- Temporary/Short-Term -- reliability support
    - Ginna RSSA (2015-17) = $83+ million/year
    - Transmission Upgrade = $140 million

Above-Market Contracts ("Un-Deregulation")

- Utility buys power at inflated, above-market price
- Long-Term Contracts
    - Ohio: Davis-Besse + coal plants, 8-15 years -- "black box" price, no review
    - Connecticut: 5+ years -- "public interest" review

Direct Market Interference -- legally vulnerable

Subsidy Models

Nuclear Emissions Credits

- Adopted: New York and Illinois
- Proposed: Ohio, New Jersey, Pennsylvania
- Direct subsidy disguised as RECs
  - Nuclear defined as "low-carbon" or "zero emissions"
  - Utilities required to purchase LCECs/ZECs
- Non-competitive -- only nuclear eligible
  - Price set by formula
  - RECs are priced in competitive markets
- Long-Term Subsidy -- 10+ years

New York ZEC Model

Nuclear Zero Emissions Credits (ZECs)

- Created by Public Service Commission regulation
- Targeted to "Publicly Necessary" reactors
  - PSC determination based on five criteria
    - Primarily, risk of closure
    - Administrative decision - no evidentiary record
- 12-year Contract (2017-2029)
  - State commits to buy ZECs from reactors
  - Load-Serving Entities required to buy ZECs from state
    - No exceptions - even 100% renewables consumers

New York ZEC Model

ZEC Price Formula

- One ZEC per MWh of generation
- Total ZEC cap set at 94% capacity factor

Based on Social Cost of Carbon

- EPA estimate of total global impact of CO2 emissions
    - Cost rises rapidly over time
    - Set in 2-year "tranches" (total of six)
- Conversion factor: from $ per ton CO2 to $/MWh
    - Assumes nuclear replaced with 100% fossil fuels

Adjustment factors

- Cap-and-Trade price: ~$5/MWh
- Market revenue projections: amount above $39/MWh
- SCC conversion factor review (after Tranche 3)

New York ZEC Price Formula

Social Cost of Carbon − **RGGI Baseline** − **Market Sales over $39/MWh** = **ZEC Price ($/MWh)**

Tranche	SCC	RGGI	Market Adj.	ZEC Base
2017-2019	$23.08	$5.61	$0	$17.48
2019-2021	$25.19	$5.61	?	$19.59
2021-2023	$26.98	$5.61	?	$21.38
2023-2025	$29.43	$5.61	?	$23.83
2025-2027	$32.06	$5.61	?	$26.45
2027-2029	$34.75	$5.61	?	$29.15

New York ZEC Costs

Annual and Total Subsidy Costs per Reactor

	Capacity	Avg. Generation	Cost Year 1	Cost Year 12	TOTAL
Ginna*	581 MW	4,784,186 MWh	$83.6 M	$139.5 M	**$1.32 Billion**
FitzPatrick	838 MW	6,900,427 MWh	$120.6 M	$201.1 M	**$1.90 Billion**
Nine Mile 1*	621 MW	5,113,562 MWh	$89.4 M	$149.1 M	**$1.41 Billion**
Nine Mile 2	1,311 MW	10,795,298 MWh	$188.7 M	$314.7 M	**$2.98 Billion**
TOTAL	3,351 MW	27,593,474 MWh	$482.3 M	$804.3 M	**$7.61 Billion**

**** Reactors to close in 2029, when 60-year operating licenses expire.***

New York ZECs vs. Renewables

Clean Energy Standard

- Includes 50% Renewables by 2030
- Nuclear Subsidy Program

Nuclear Subsidy: $7.6 Billion cost

- 2017-2029: 27.6 million MWh/year
- 2030: ≤ 17.7 million MWh

Renewables 4 Times as Cost-Effective

- Total RECs Cost: $2.4 Billion
- New Renewables 2030: 33.6 million MWh
- 70% lower cost for 25% more energy

No Alternatives to Nuclear Considered

- Energy Efficiency Study:
- 25.4 million MWh by 2030 -- $3 billion net savings
- 92% of max nuclear -- 143% of 2030 nuclear -- $10.6 billion lower cost

Illinois Nuclear Subsidy

Follows New York Model

- Based on Social Cost of Carbon
- Three unprofitable reactors
- 10-year contract (2017-2027)
- Legislation includes fixes to RPS, energy justice

55% Lower Cost than NY

- $2.35 billion for 2,889 MW of nuclear

Main Differences

- Lower SCC price
    - Starts at $16/MWh instead of $23.08
    - No increases until 2023
- Lower market price threshold
    - $31.40/MWh, not $39
- Total Subsidy Cost Cap
    - 2% of 2009 utility bills

National Cost Projection

New York Model

- Illinois cost controls state-specific
- Most states have no carbon price

Possible Mechanisms

- DOE task force - nuclear Production Tax Credit
- FERC - market for reliability and/or carbon products

Considerations

- All Nuclear or "At-Risk" Reactors Only
  - Range: $160 billion to $286 billion
- Rationality: must be legally defensible

Nuclear in the Transition

How to deal with reactor closures?

Two answers:

1. **No problem** -- renewables and efficiency can do the job
   - Nuclear = 19% of U.S. electricity (8.4% of all energy)
   - ***2% Efficiency = 21% by 2030***

2. **Make a Plan**
   - Phase-Out: nuclear, fossil fuels
   - Ramp Up: renewables, efficiency, storage, etc.
   - Just Transition: safety net for workers, communities

Diablo Canyon Phase-Out Plan

June 2016 Agreement: Nuclear-Free California

- PG&E + Enviros + Labor
- Licenses expire in 2024 and 2025

PG&E: Nuclear Blocks Renewables

- California RPS: 50% by 2030
- Nuclear is inflexible - forces "curtailment" of solar, wind by mid-2020s

Clean Energy Replacement

- Extra Energy Efficiency: 4 million MWh by 2030
- 55% Renewable Energy by 2030

Community and Workers: Just Transition

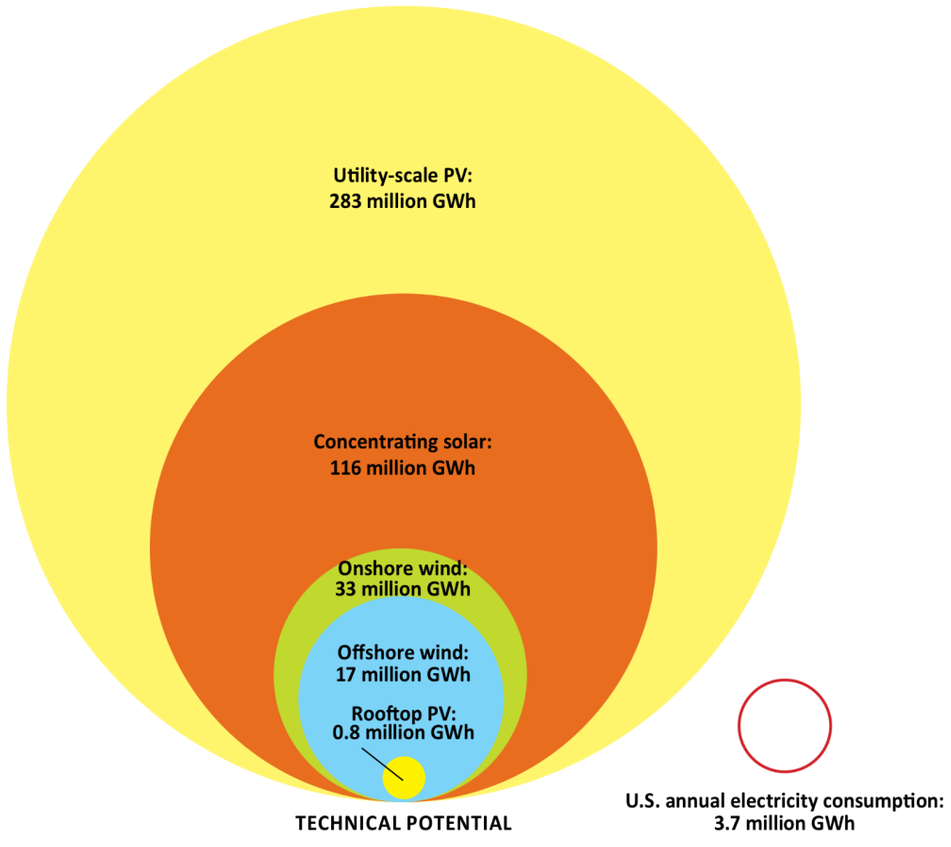
- Prompt Decommissioning -- retain workers for cleanup
- PG&E re-hiring, transfer + retraining
- Property Taxes continue through 2025

Renewable Energy Feasibility

Research is in: 100% Renewable by 2050 is Feasible

- Carbon Free and Nuclear Free, IEER (2007)
- Reinventing Fire, Rocky Mountain Inst. (2011)
- Env. America survey: 7 other studies

Figure ES-1: Comparison of Renewable Energy Technical Potential and Current Consumption (Data: NREL)



100% renewable

=

nuclear-free

+

carbon-free

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New Reactors ... Same Old Problems

"[D]espite the much-ballyhooed ingenuity of a new generation of reactors designed by the likes of Westinghouse and G.E., countries may stick with older technologies that they can produce and install more quickly and cheaply."

New York Times - "The Murky Future of Nuclear Power in the U.S."

February 18, 2017

"The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale. The utility industry has already invested $125 billion in nuclear power … only the blind, or the biased, can now think that most of the money has been well spent."

Forbes Magazine - "Nuclear Follies"

February 11, 1985

Renewables vs. Fossil-Nuclear

Energy System Transition

- Obsolete Concepts: "Baseload" and Fuel Diversity

"Engineers love nuclear power because there are so many problems to solve."

"Nuclear power is 24-7 ... until it is 0-365."

"The industry wants us to believe that we can figure out how to store nuclear waste for 1 million years, and that we can't figure out how to store electricity overnight."

"Advanced" Reactors?

Same Problems ... Only Worse

- Too Dirty ... *even more so*
- Too Dangerous ... *different technology, different problems*
- Too Expensive ... *likely even more so*
- Too Slow ... *always 20-30 years away*

What's on the Menu?

- Small Modular Reactors (NuScale, Holtec)
- Thorium Reactors
- Liquid Sodium Reactors (TerraPower)
- Molten Salt Reactors (TransNuclear)

"Advanced" Reactors?

Small Modular Reactors (SMRs)

- 50-300 MW each (Yankee Rowe = 185 MW)
- Not so modular - NuScale designed for 12 reactors
- No Experienced Manufacturers
  - Westinghouse, B&W canceled SMRs
- Assembly Line Production
  - What about recalls?

Thorium Reactors

- Thorium is not fissile
  - Converted to U-233 by neutron bombardment
- Requires Reprocessing
  - Massively dirty and expensive: West Valley, Hanford, Sellafield, Chelyabinsk
  - Proliferation Risk: Plutonium-239 + Uranium-233
- No Climate Solution: Th at least 40-60 years away
  - India Thorium Plan: LWRs ➡️ Breeders ➡️ Thorium

"Advanced" Reactors?

Liquid Sodium Reactors (TerraPower)

- Plutonium Breeder technology (reprocessing)
  - Never Proven: Fermi 1, Monju, Superphénix
- Liquid metal coolant
  - Sodium melts - Heat exchanger boils water
  - Sodium explodes in contact with water
    - Fermi 1 meltdown (1966) - *We Almost Lost Detroit*

Molten Salt Reactors (TransNuclear)

- Old Idea, New Twist
  - Even farther from testing, licensing, commercialization
- Requires On-Site Reprocessing
  - Proliferation risk: Protactinium-233 ➡️ Uranium-233
- Extremely radioactive, long-lived waste products