

# Nuclear Energy in a Shifting Landscape

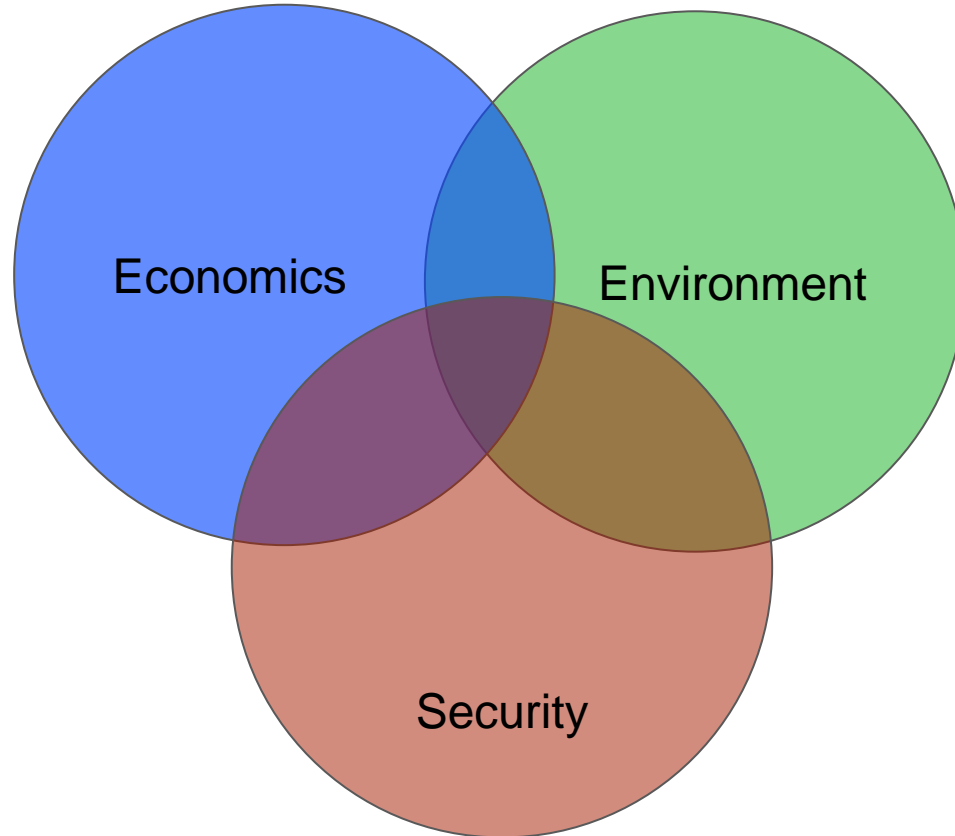
Paul P.H. Wilson  
Department of Engineering Physics  
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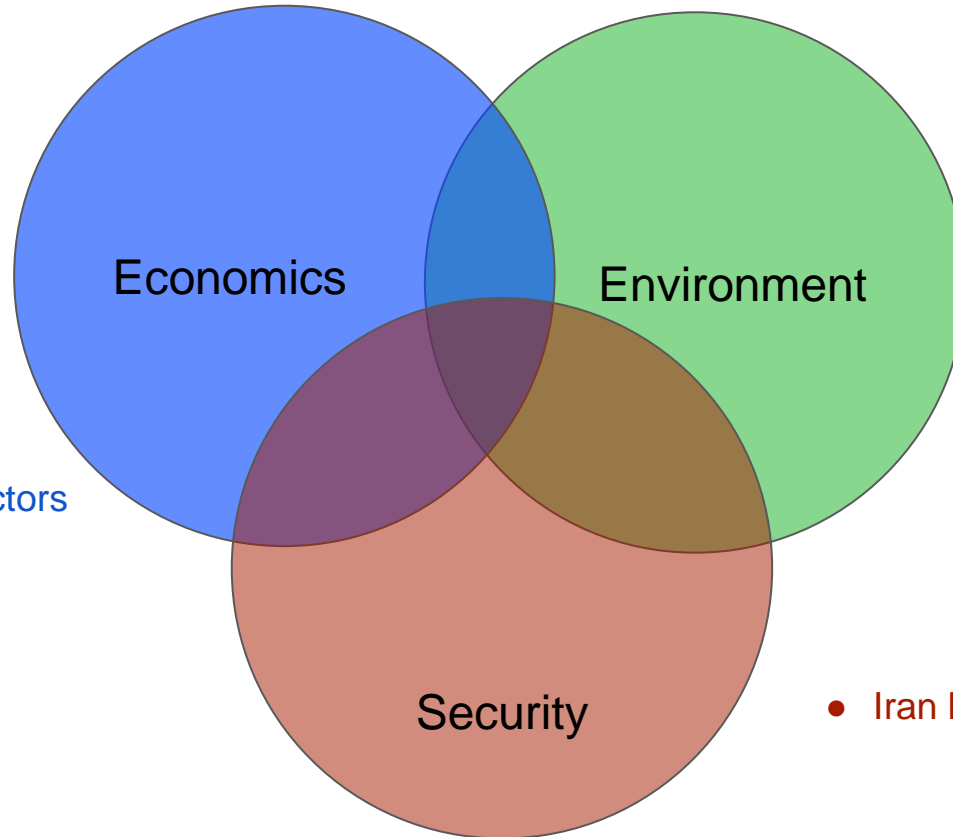
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# Energy Policy in a Nutshell



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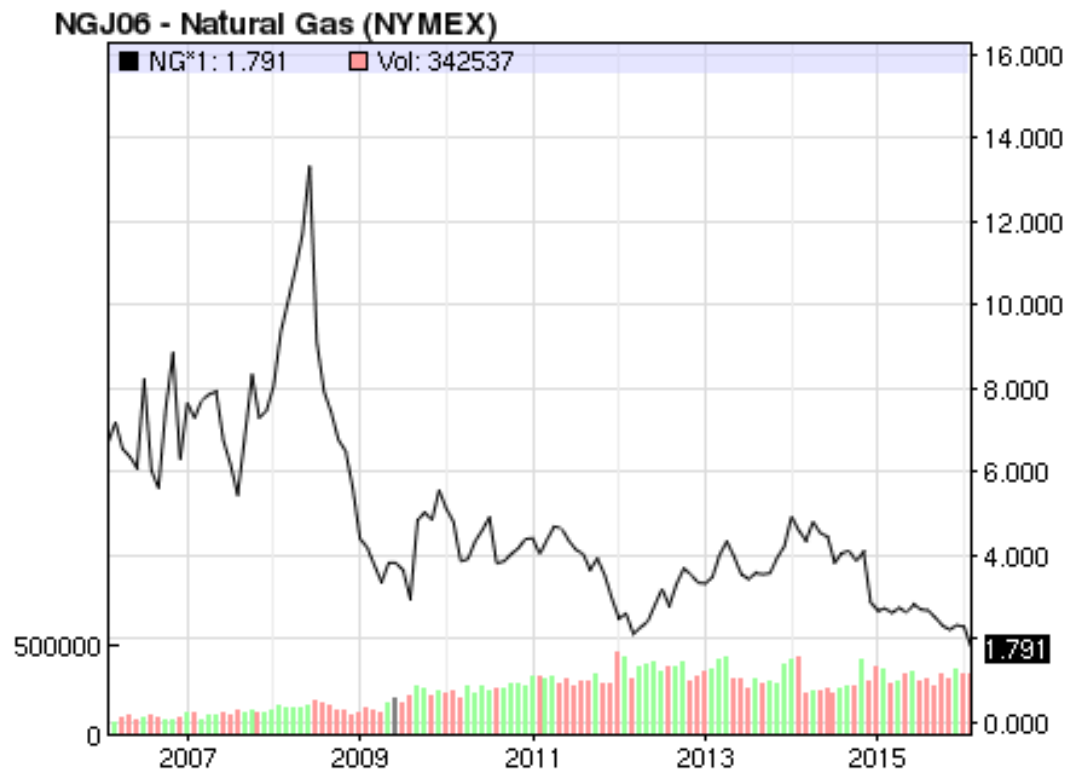


- Cheap Natural Gas
- Energy Markets
- Small Modular Reactors

- Clean Power Plan
- Yucca Mountain
- Radiation Risk

- Iran Nuclear Agreement

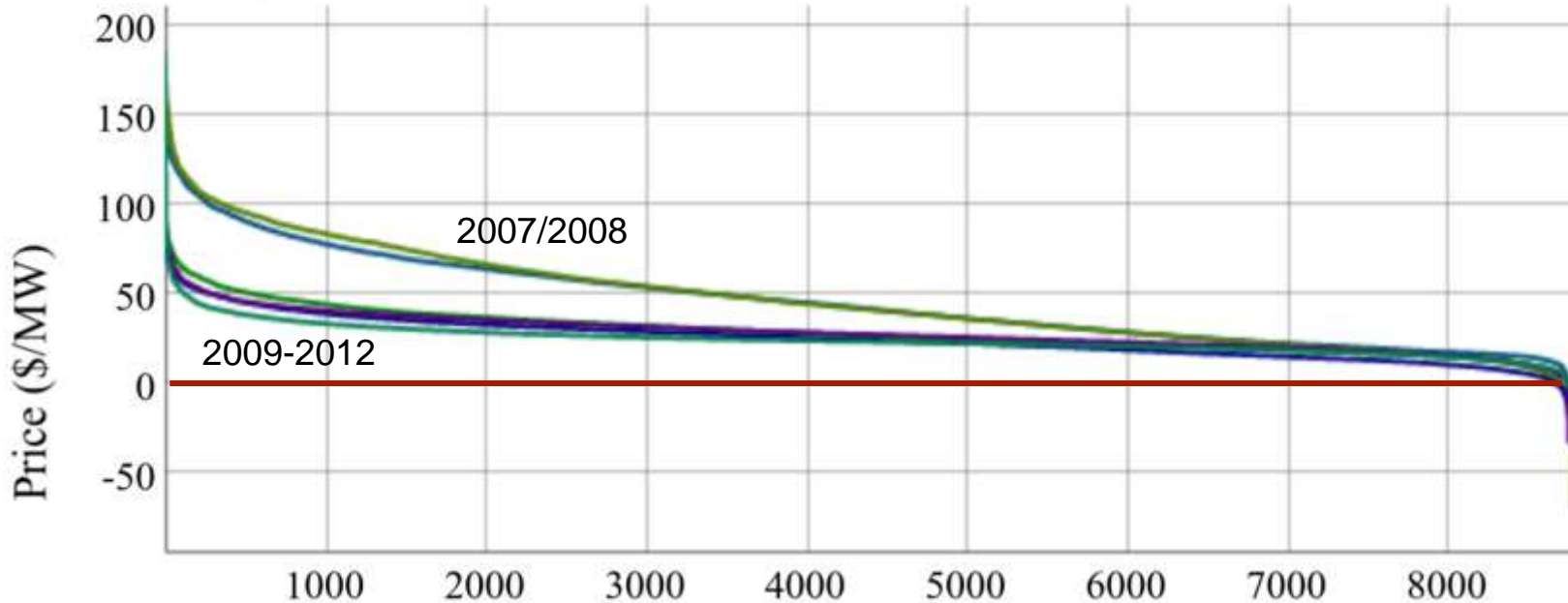
# Cheap Natural Gas



# Cheap Natural Gas

45% revenue reduction from 2008 to 2009

## Day-Ahead Price Duration Curves for Kewaunee



# Cheap Natural Gas

## Riding the decline in natural gas prices

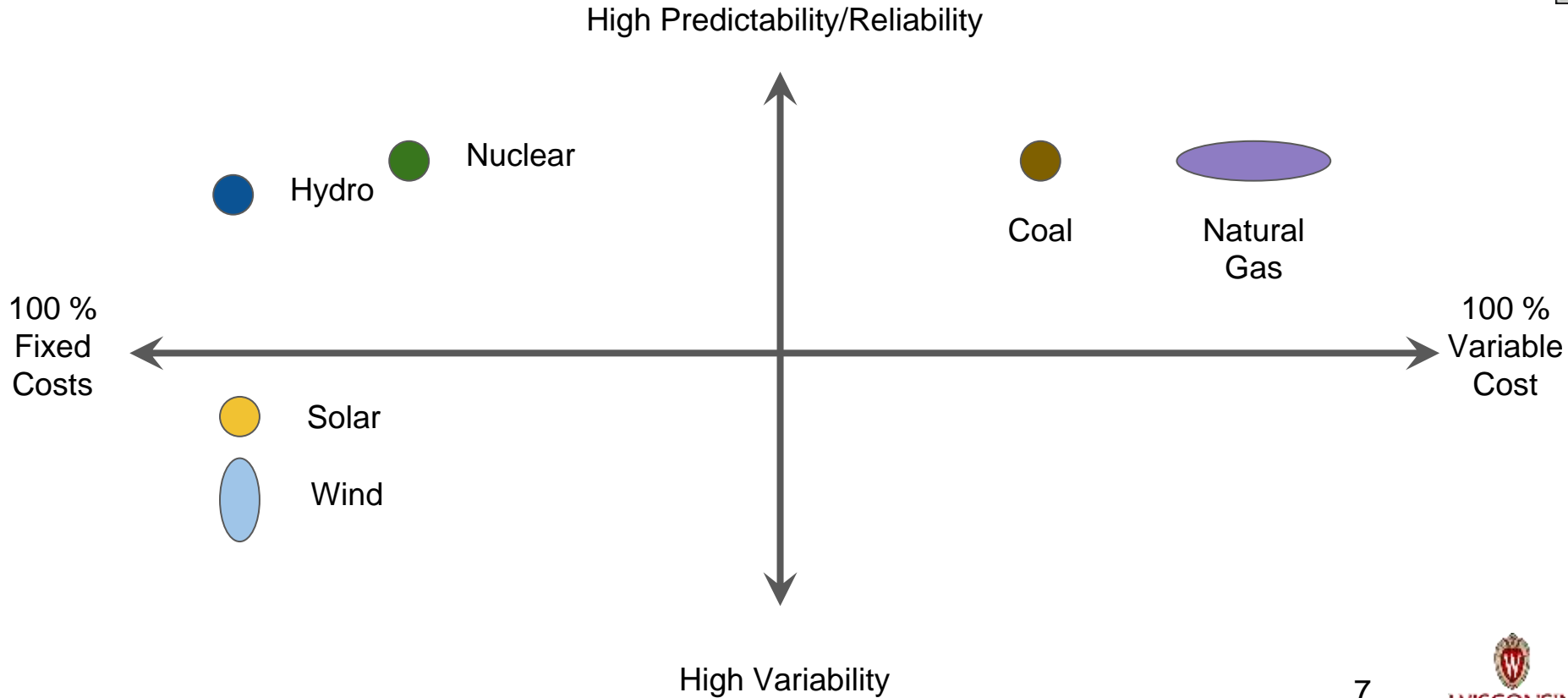
Rapid construction of natural gas plants allow electricity system to quickly follow

## Weathering an increase in natural gas prices

If vs When

Alternatives tend to have longer construction/lead times

# Energy Market Structure



# Energy Market Reforms

## Capacity markets

Reward generators for dispatchable capacity

## Greenhouse gas markets

Charge generators for external costs

## Reregulation

Recognize societal value of generation

## Must justify societal need

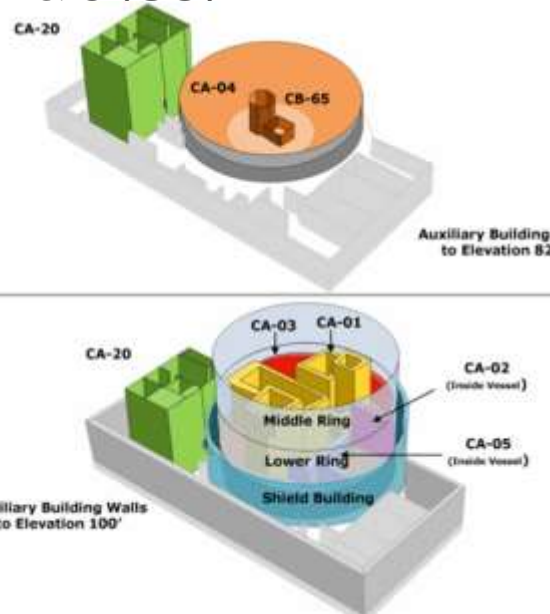
Not just to “save” nuclear energy



# New Nuclear Construction

Watts Bar 2 (TN)

Summer 2 & 3 (SC)



Vogtle 3 & 4 (GA)



# Small Modular Reactors

Construction of new large reactors has challenges

- Large single investment

- Long construction time lines prior to revenue generation

- Deregulated markets mean no guaranteed rate of return

## Small modular reactors

- Reduce size of initial investment

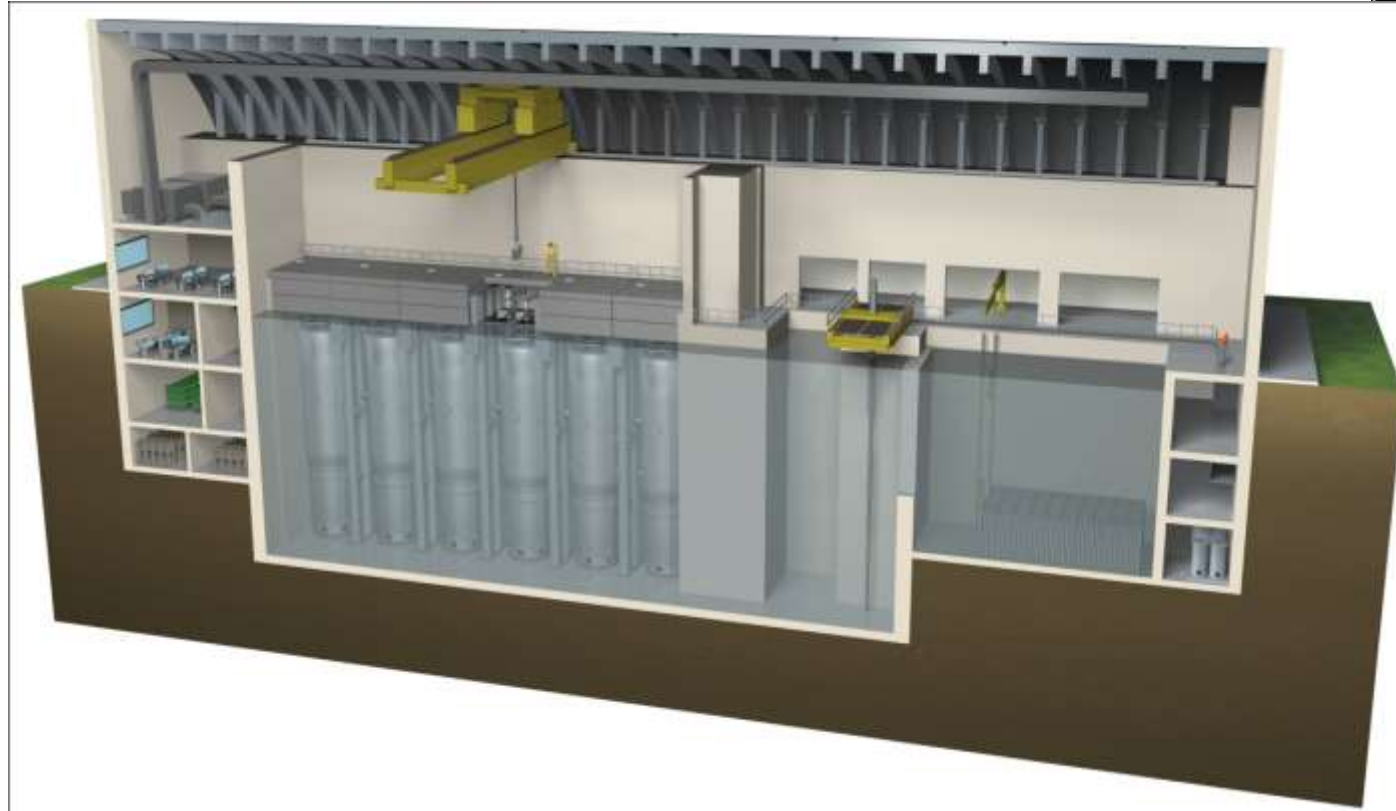
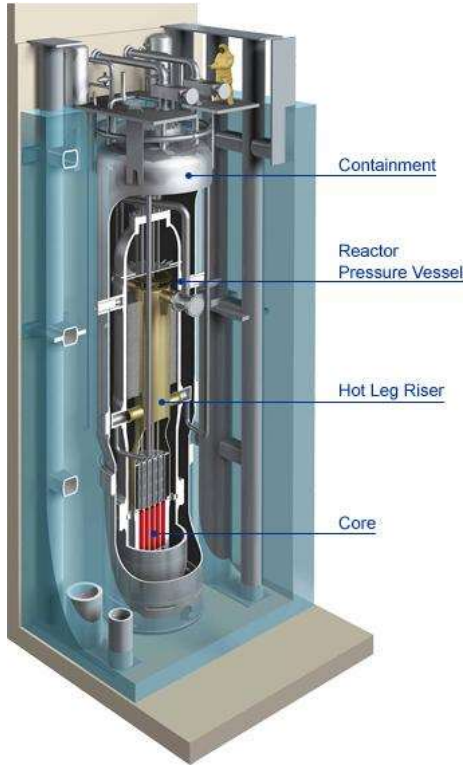
- Shorten construction time line with factory manufacturing

## Economy of scale

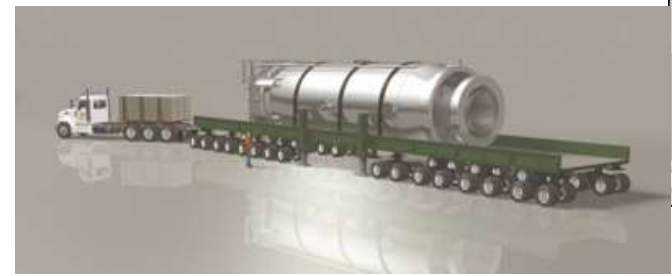
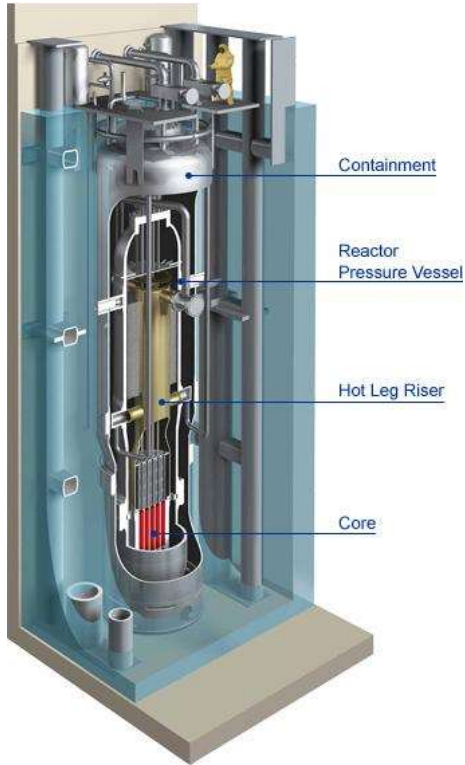
# Small Modular Reactors



# NuScale



# NuScale



Factory manufacturing

Shipped by truck, rail, barge

Skid-mounted steam turbine/generator

Fueled every 24 months in 10 days

(98% capacity factor)

Each module installed in isolated bay

# EPA Clean Power Plan

**Overarching Goal: Reduce greenhouse gas emissions**

Rate Based Goal: Reduce emission rate from coal/oil/natural gas

Credit given for

- Increasing efficiency of coal/oil plants

- Shifting coal to natural gas

- Shifting coal & natural gas to new nuclear/renewables

No incentive to keep existing renewables/nuclear

# EPA Clean Power Plan

**Overarching Goal: Reduce greenhouse gas emissions**

Mass Based Goal: Cap total emissions from coal/oil/natural gas plants

Defines how much new nuclear/renewables necessary to offset new coal/oil/natural gas plants

Incentive for building new nuclear/renewables

No incentive to keep existing renewables/nuclear

# EPA Clean Power Plan

## Comparing Nuclear & Renewables

Both treated equally by CPP

Nuclear >60% of current low-emission generation

Renewables ~15% of current low-emission generation &  
sheltered by

- Renewable portfolio standards

- Production tax credits



# Used Nuclear Fuel Disposal

## 1982 - Nuclear Waste Policy Act

USDOE responsible for ultimate disposal of used nuclear fuel  
beginning 1998

Nuclear Waste Fee/Fund established

## 1987 - Nuclear Waste Policy Act amended

Yucca Mtn, NV, selected

## 2002 - Yucca Mtn officially site recommended by Secretary of Energy

## 2008 - USDOE files license application with USNRC for Yucca Mtn repository

## Used Nuclear Fuel Disposal

2010 - USDOE (attempts to) withdraw license with prejudice

2013 - Court rules that license cannot be withdrawn (see 1987 law)

2014 - USDOE stops collecting waste fee

2015 - US NRC releases 5-volume safety report confirming safe disposal of used nuclear fuel at Yucca Mtn

2016 - USDOE initiates consent-based siting program

# Radiation Risk

Long standing scientific debates regarding risks of low-level radiation exposure

Regulation limits based on extrapolating high doses to low doses assuming no threshold

Average US public exposure from natural and medical sources: ~0.6 rem/yr

Public exposure limit from nuclear energy: 0.1 rem/yr

Normal radiation worker exposure limit: 5 rem/yr considered safe

# Radiation Risk

Relative risk of evacuation vs low-level radiation exposure [1]

## Fukushima

estimates for addition cancers  
without evacuation < 160

estimates for fatalities due to  
evacuation ~1600

[1] "When Radiation Isn't the Real Risk," New York Times, 9/21/15, <http://nyti.ms/1OM0weR> [accessed: 9/28/15]

# Iran Nuclear Agreement

No real impact on domestic nuclear energy

Renormalized nuclear relations between West and Iran

Creates strong diplomatic pressure on all sides

Limits Iran's production enrichment capacity and technology for 10 years

Limits quantities and enrichment of uranium

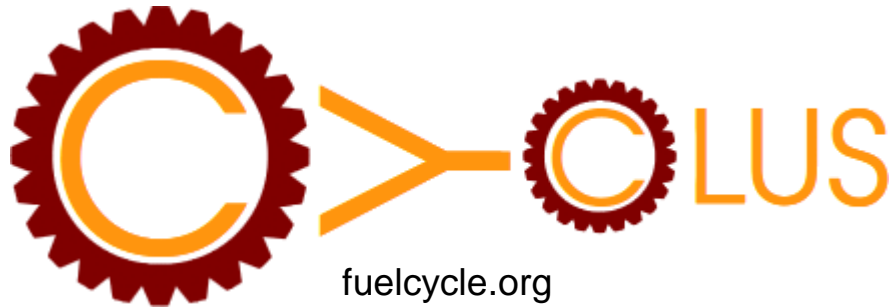
Returns to inspection regime under Additional Protocol

Bans any R&D towards nuclear weapons

What about "24 days"?

14 days of dispute + 7 days of dispute resolution + 3 days of compliance

Simply invoking this will be a high-stakes diplomatic measure



Simulate impacts of technology choices over century time scales

Nuclear electricity costs

Couple with full energy system models

Resource consumption

Environmental impacts

Emissions

Radioactive waste disposal

Non-proliferation goals

# Questions?

paul.wilson@wisc.edu



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