Nuclear Power

Climate, health & environment

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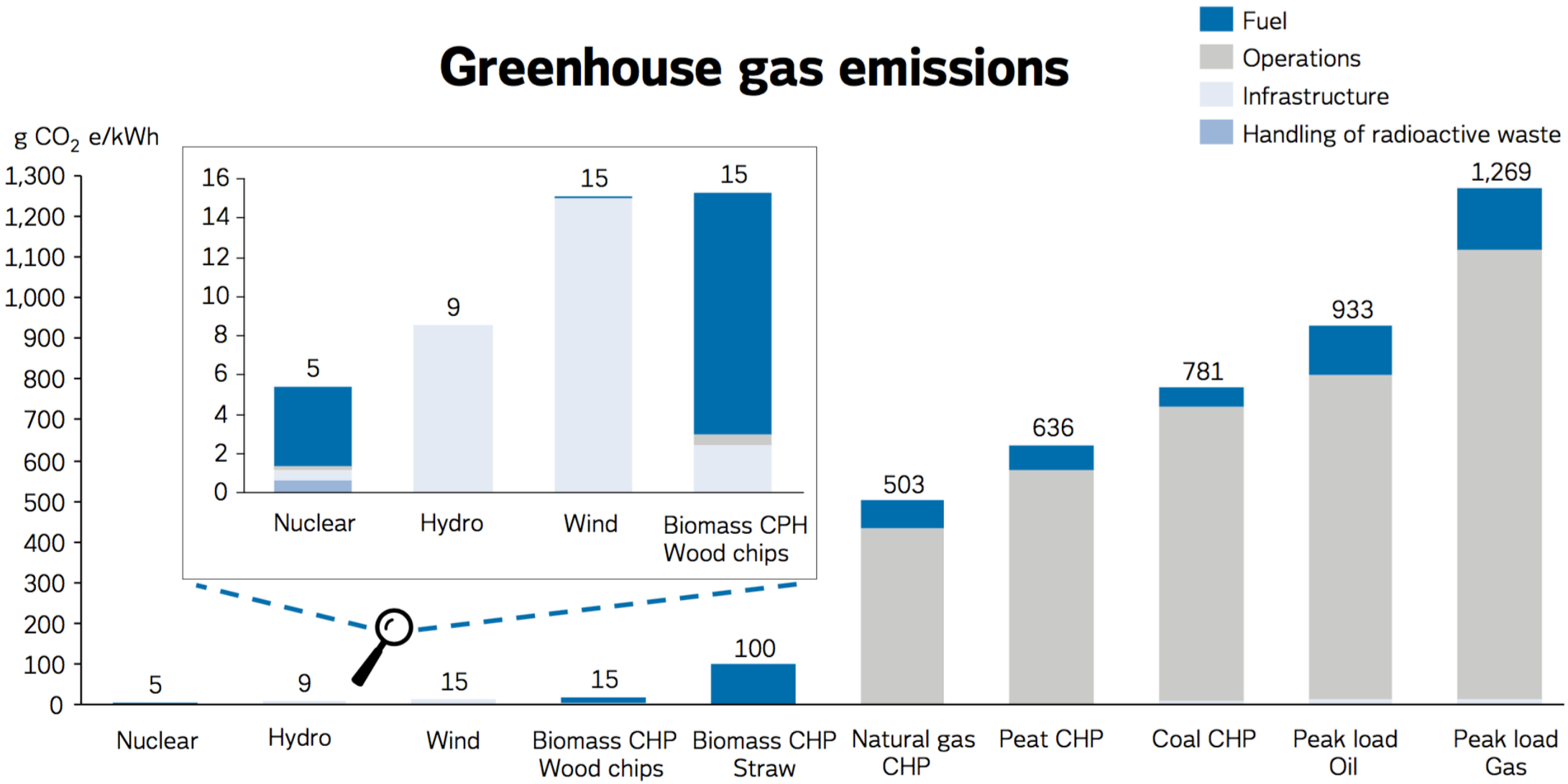
Presentation at Elforsk seminar

January 20th 2016

GHG emissions from electricity

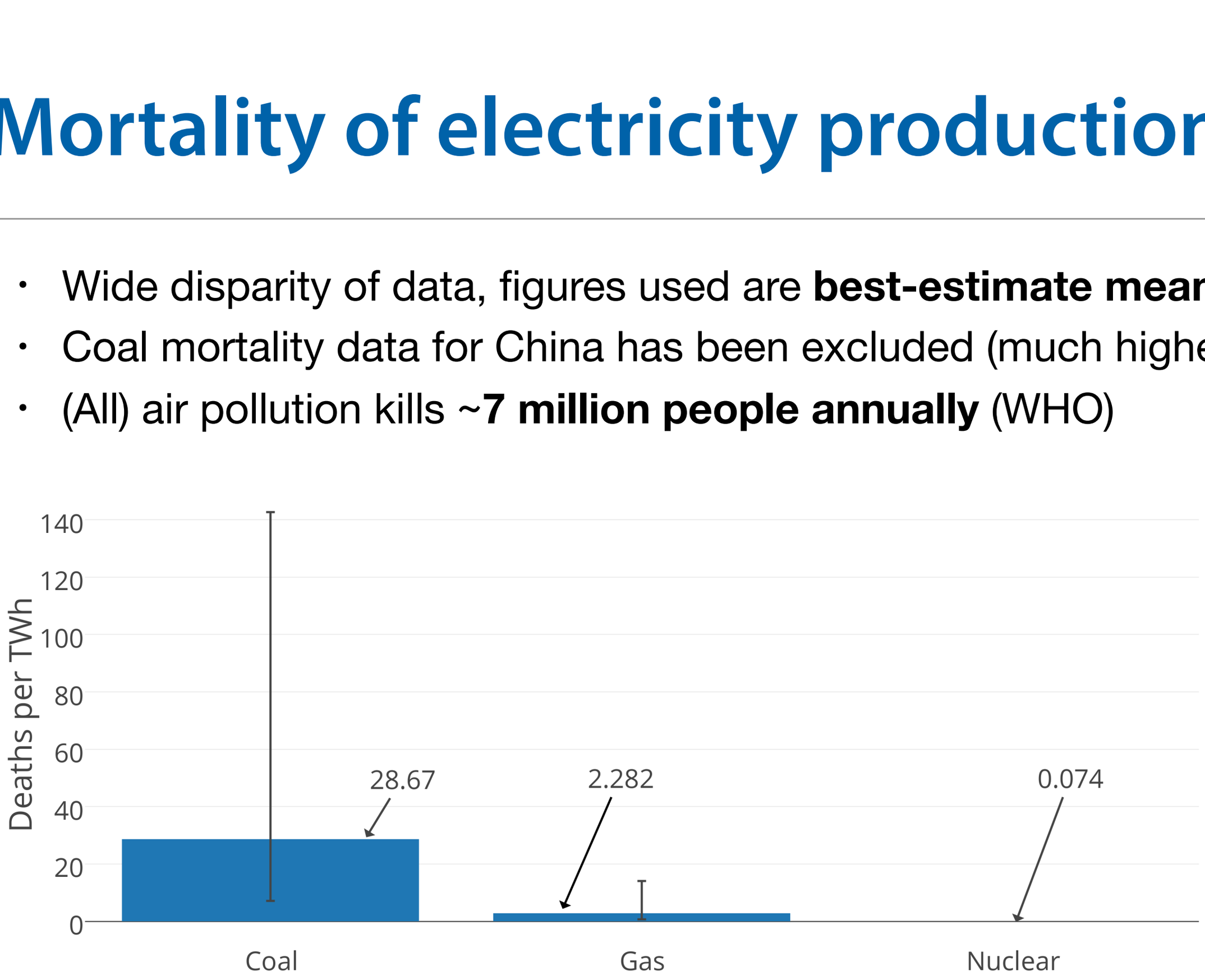
- Nuclear typically 5-50 gCO_2/kWh
- Coal at 800-1300 gCO_2/kWh



Vattenfall LCA Study (July 2012)

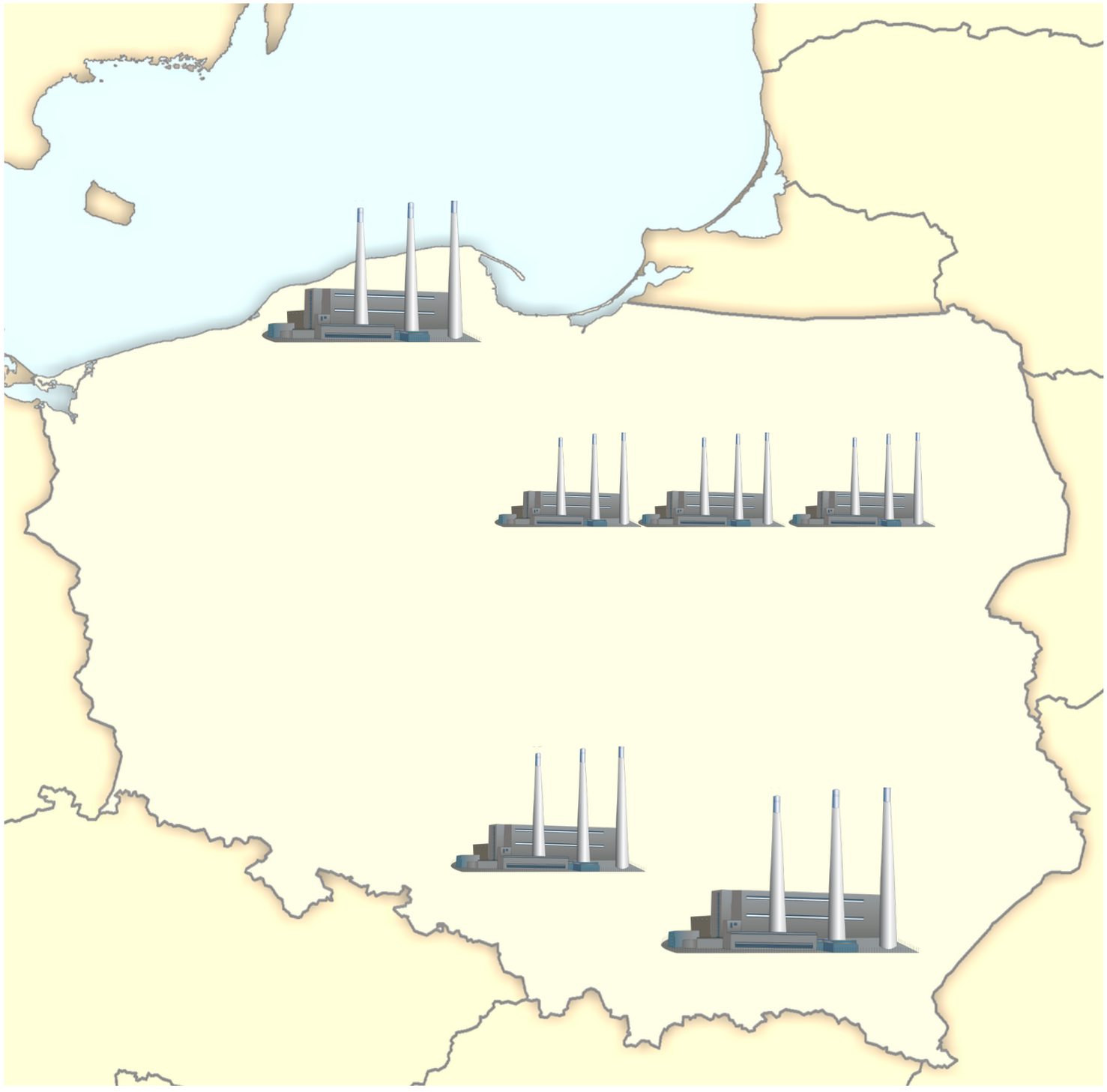
Mortality of electricity production

- Wide disparity of data, figures used are **best-estimate mean**
- Coal mortality data for China has been excluded (much higher)
- (All) air pollution kills **~7 million people annually** (WHO)



Markandya, A.; Wilkinson, P. Electricity generation and health. **Lancet 2007, vol. 370, p. 979–990.**

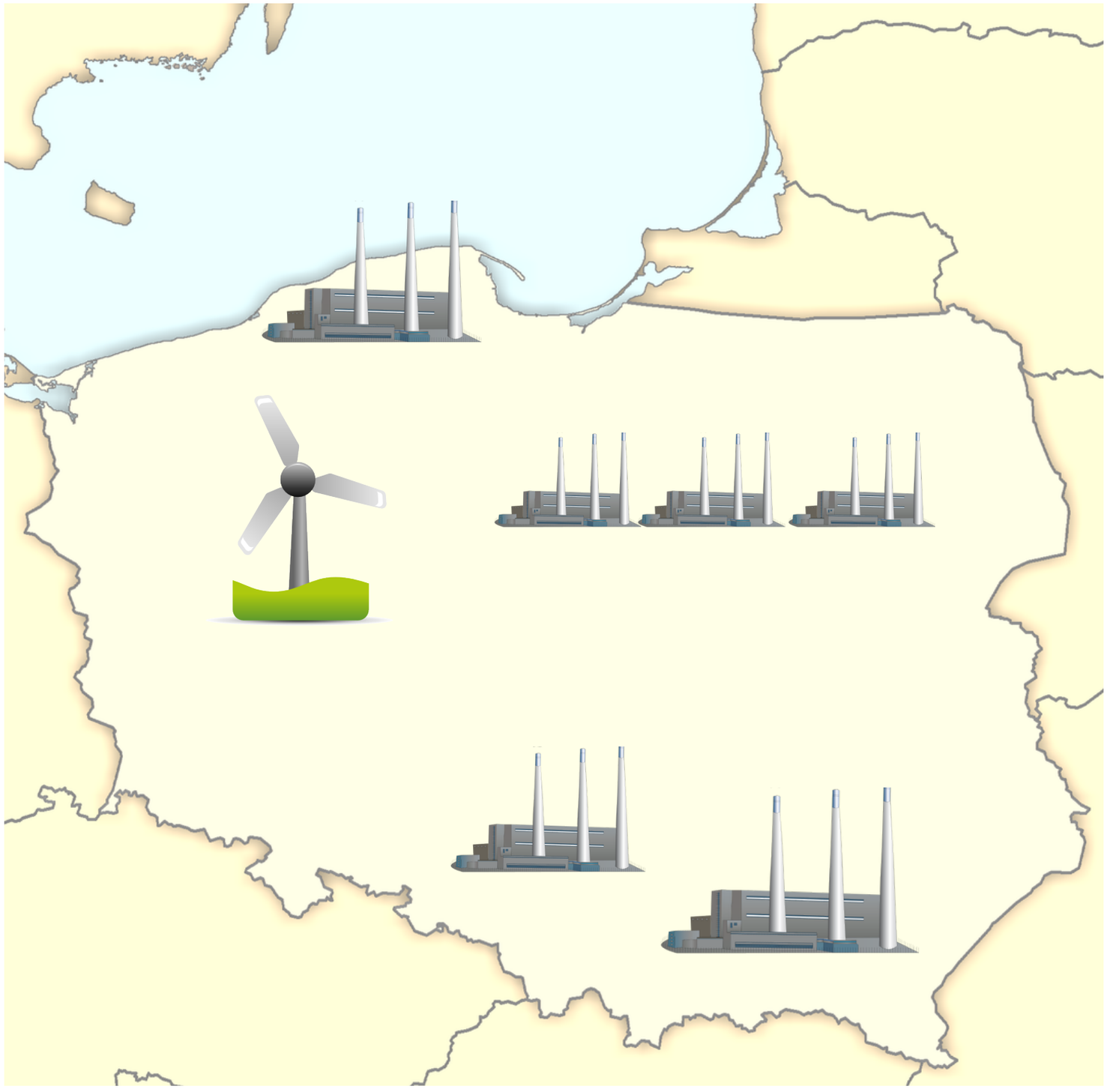
Principles of "replacement" capacity



- Polish domestic electricity production is almost entirely based on coal

- Building just about *anything else* on the grid connected to Poland to "replace" part of this would be good for the climate

Principles of “replacement” capacity



Poland decides to build a wind farm with an annual production equal to a coal power plant

The wind farm is paid for, built, and ready to operate for the next 20-25 years

Principles of “replacement” capacity

Politicians then decide to **not connect** this built-and-paid-for wind farm to the grid.

Is this decision good or bad for the climate?

The decision does not **increase** emissions, but naturally we can think one step further…

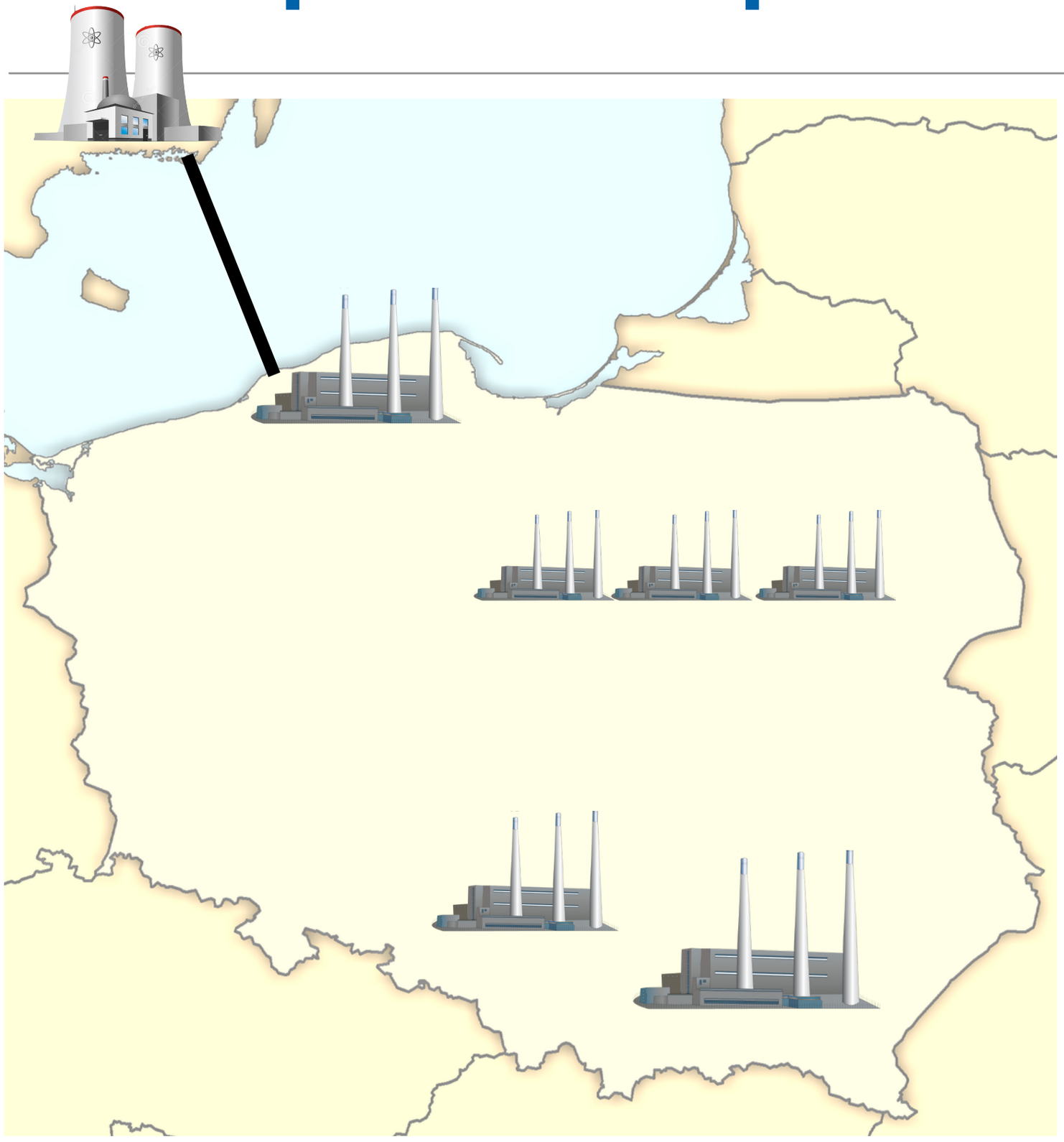
Principles of “replacement” capacity

Politicians then decide to build solar farms to “**replace**” the wind farm

Does this decision improve the decision to not connect the wind farm to the grid?

Has the “climate impact” of not connecting the <u>wind farm</u> changed in any way?

Principles of “replacement” capacity

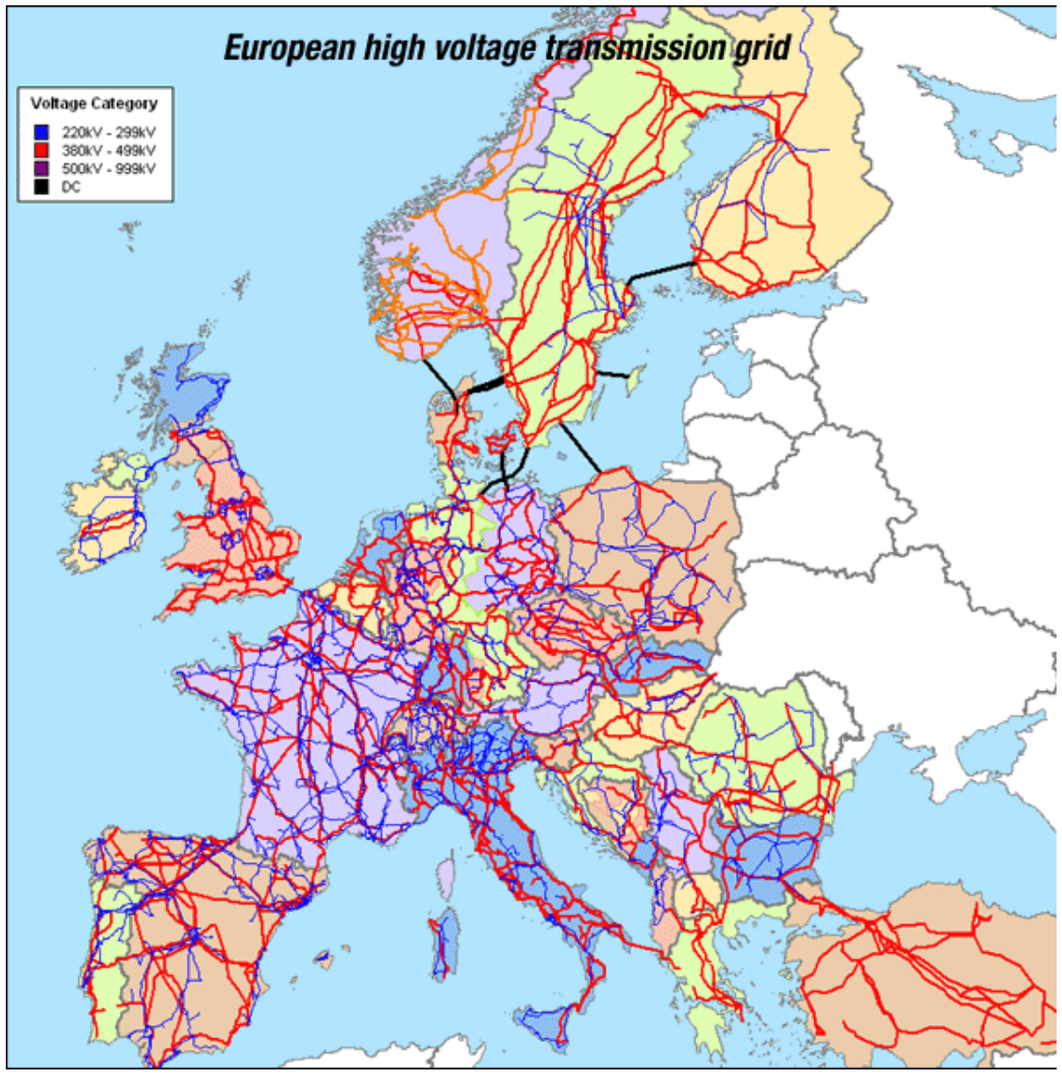


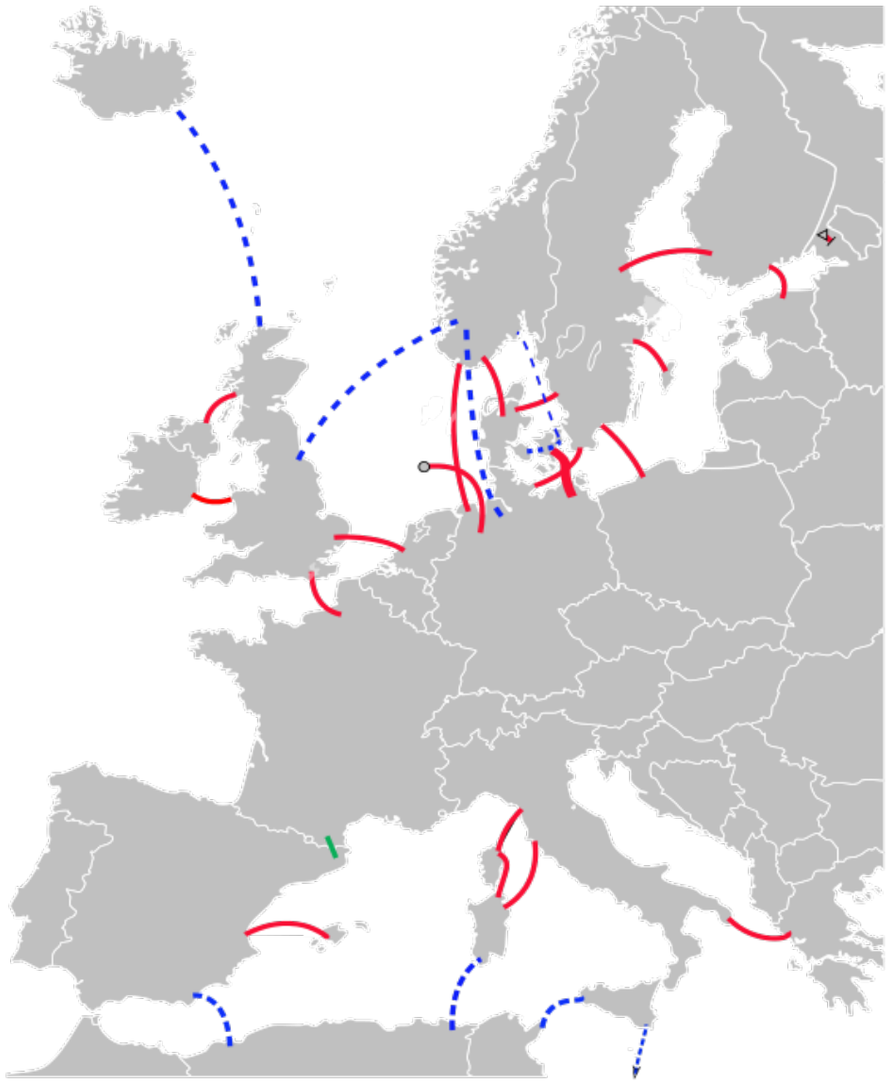
Is it good or bad for the climate to shut down nuclear plants and try to **“replace”** them with wind and solar plants?

Does this “replacement” improve the original decision to shut down nuclear and does it reduce the climate impacts of **that decision?**

European electricity grid

- Electricity produced **is** consumed somewhere in the grid
- Non-emitting sources **effectively displace** emitting sources





Quick note on renewables

“The wind always blows somewhere”

Combined minimum wind capacity factor across EU (11 nations):

1h: 2.3%, 24h: 5.3%, 48h: 6.0% (SWE 48h: 2.8%)

“It’s always sunny somewhere (during the day)”

Combined minimum solar capacity factor across EU (5 nations):

24h: 1.2%, 1 week: 2.0%, 2 weeks: 2.4%, 1 month 3.0%

“It’s always windy *or* sunny somewhere”

Combined minimum capacity of wind+solar across EU (16 systems):

1h: 2.5%, 24h: 5.4%, 48h: 6.1%,1 week: 9.9%

Data from 2013

* Wind data: Germany, Spain, UK, France, Finland, Czech Republic, Sweden, Denmark, Ireland, Italy, Belgium
* Solar data: Germany, Spain, France, Czech Republic, Italy

The politics of climate insanity

Name	Bełchatów Coal Power Plant	Ringhals Nuclear Power Plant
Installed power	5420 MWe	3707 MWe
Generation y^{-1}	26 TWh	25-30 TWh
Emissions gCO_2/kWh	~1150	~5
Emissions tCO_2/y	~30,000,000	~3-4000
Status	Most polluting power station in Europe	Largest clean power station in Northern Europe
Prospects	**Recently upgraded**	**Being forced out of operation**

Elektrownia Bełchatów, Poland

Ringhals NPP, Sweden

The politics of climate sanity

1. **Don’t shut down any existing low-emissions production**
2. **Make pollution expensive**

Include external costs in the price of coal, oil and gas

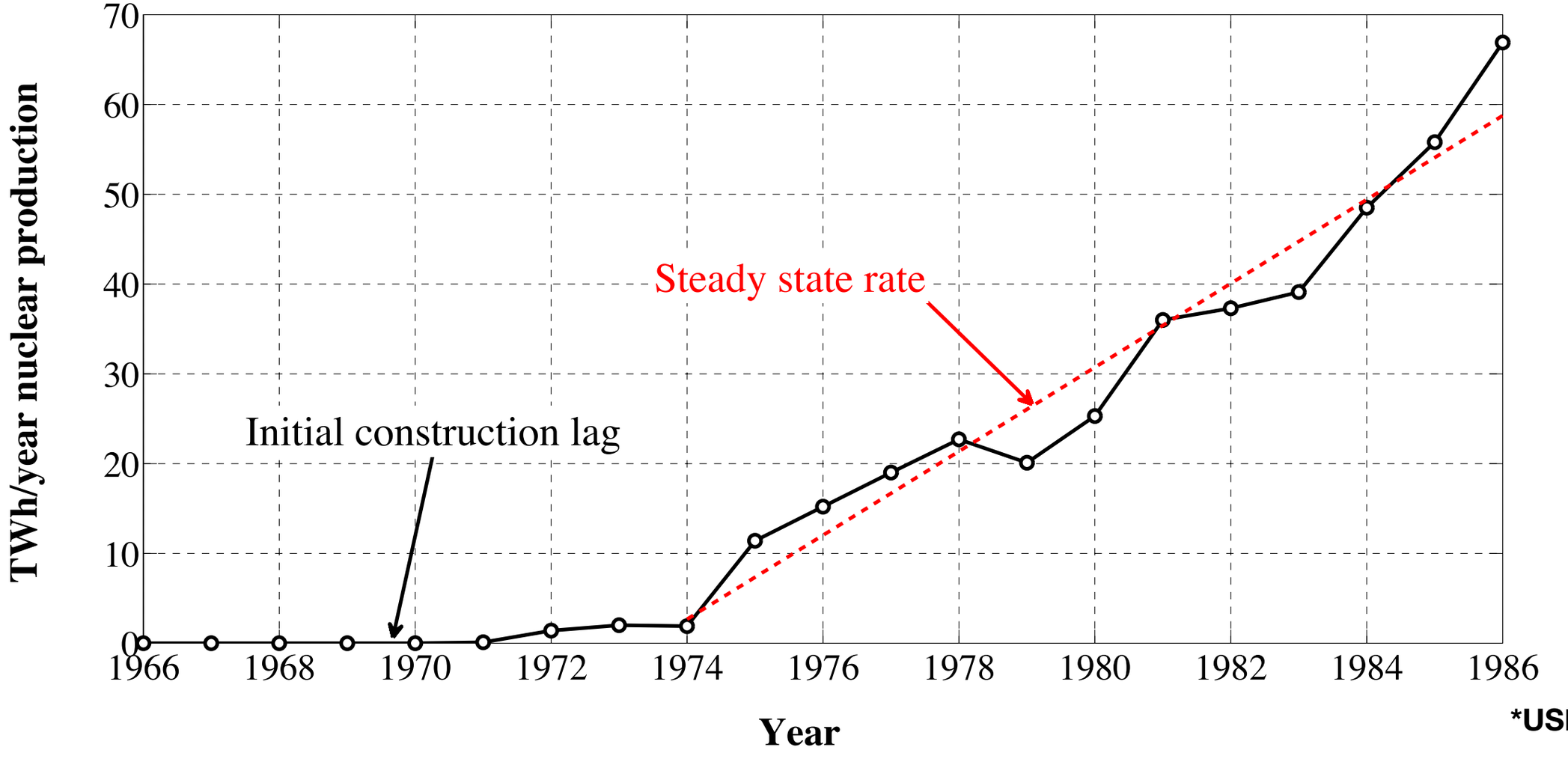
3. **Build new low-emission energy production, by either:**
    A. Implementing (a rational) national strategy
    B. Let a free (actually free) market system decide what to build
4. **Fund research on low-emissions technology**

Including the modern versions of the most successful historical pathway to de-carbonization in history: Nuclear energy.

5. **Transition to electric (and biogas) driven transportation**

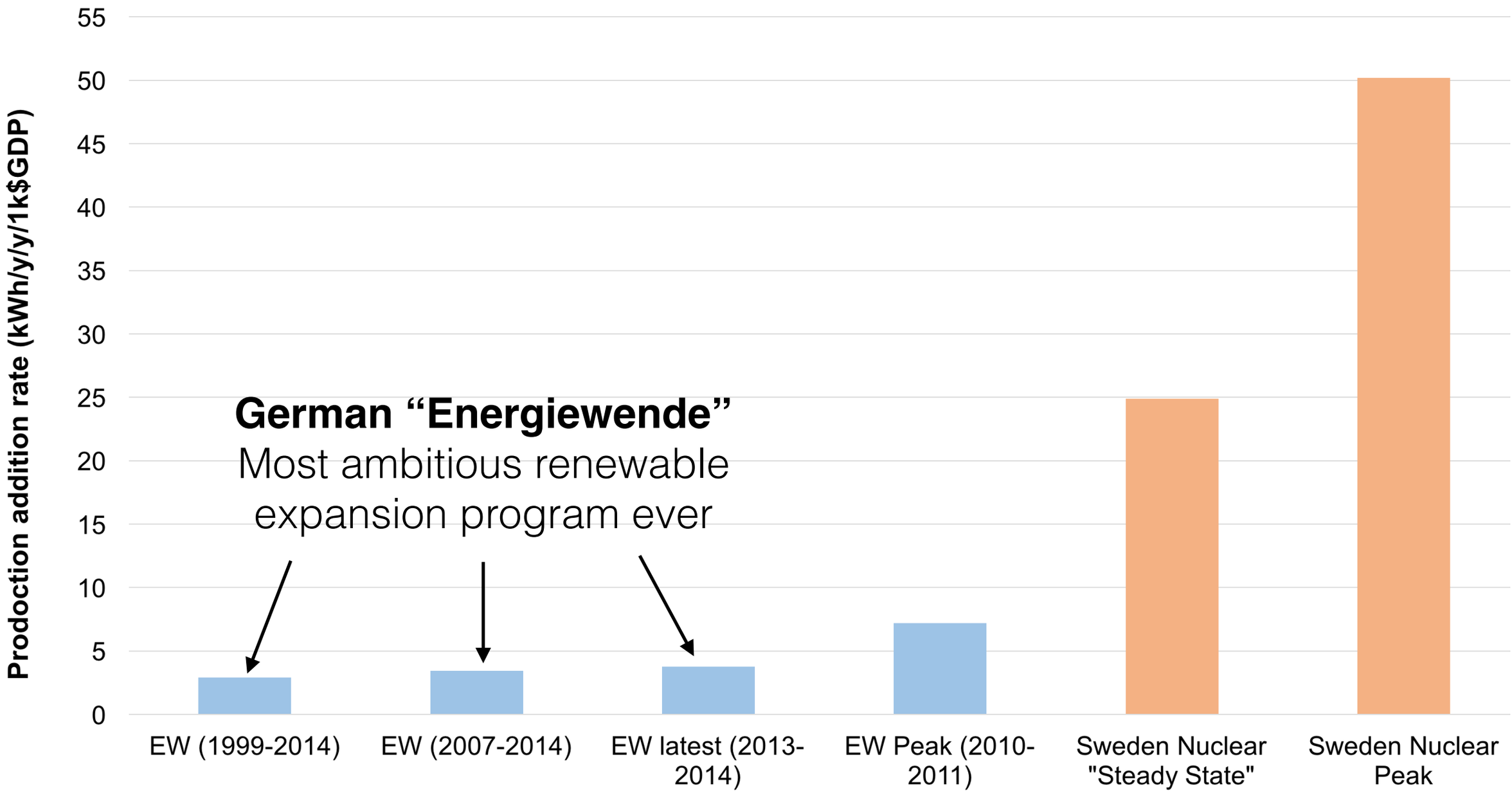
The Swedish Nuclear Program

- Steady-state rate of addition: +**25** kWh/y/y/1000$-GDP*
- Fastest addition of low-carbon energy in history
- Adjusted to global GDP: **1500** TWh/y/y (10% of fossil electricity)



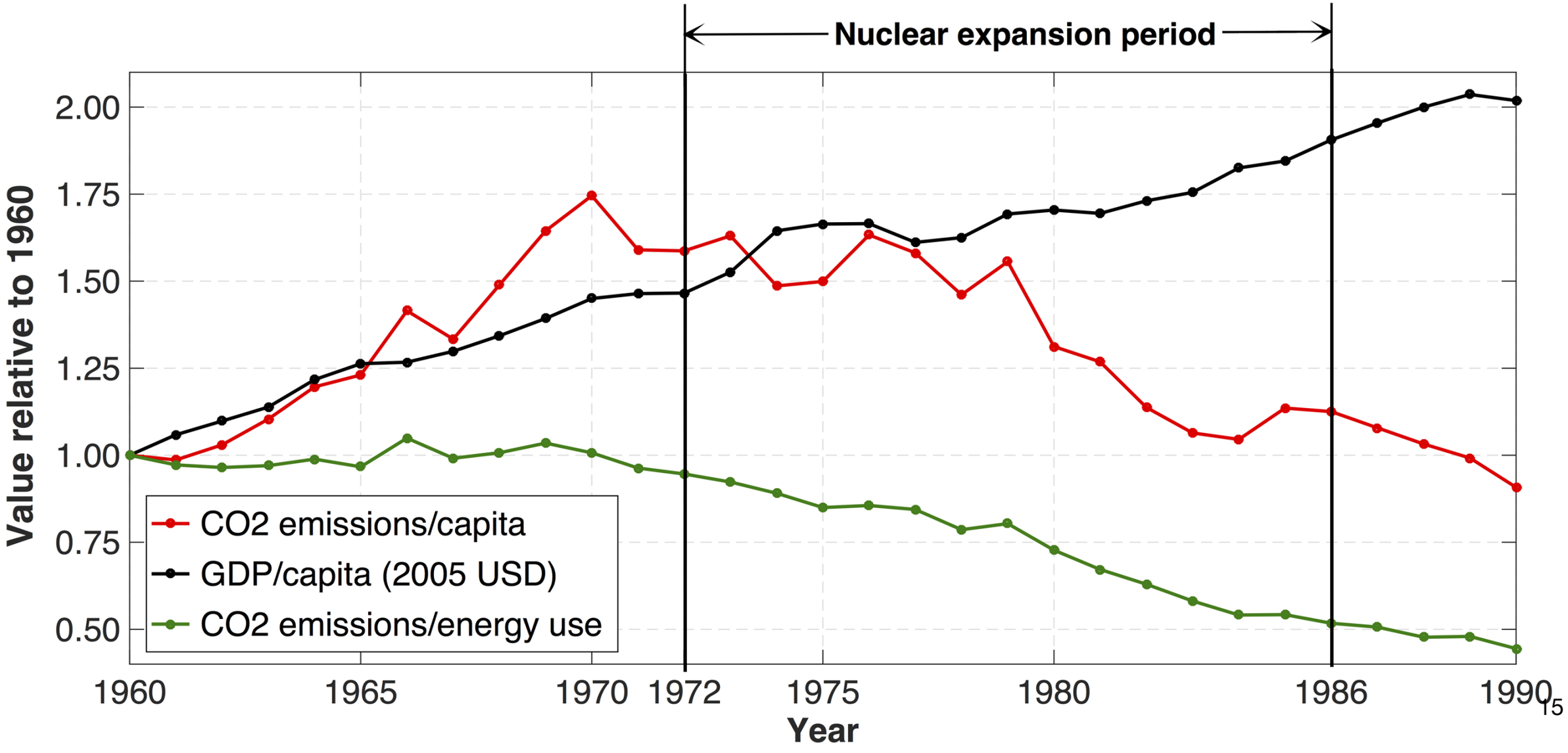
*USD in 2005

Energiewende?



Swedish Energy and Emissions

- Up until 1972: *Intensity* constant, emissions rapidly increasing
- 1972 and on: *Intensity* rapidly falling, emissions falling
- Per capita emissions down by **75%** from 1970 by ~1990



Swedish Energy and Emissions

*"The Swedish Nuclear Power Program is in many ways **the most successful climate and environmental project** that **the world has ever seen**."*

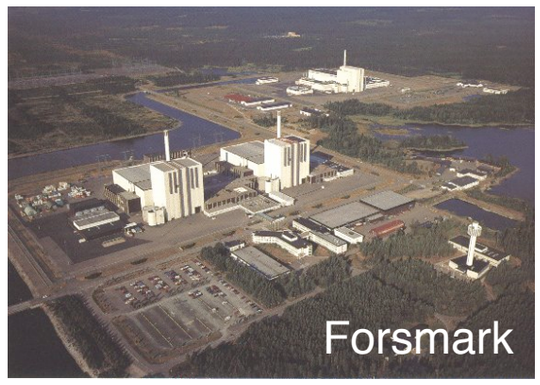
DN Debatt (22/5/2015)

Professor James E. Hansen,

World leading authority on climate science

Status of Swedish Nuclear


Ringhals


Forsmark


Oskarshamn

- To date (Oct. 2014) Swedish nuclear has produced **2133 TWh** of electricity, remaining potential is **1800-2100 TWh**
  - Swedish nuclear has reached **half-way!**
- This electricity acts (like all other emissions free electricity) to displace fossil production (coal, gas, oil)
  - To-date emissions prevention is **~2 billions tons** of CO_2
  - Future prevention potential is **~2 billions tons** of CO_2
- This production has prevented up to **60,000 energy related deaths**, with the same potential for the future.

Forcing, by excessive taxation, these plants out of operation, puts the responsibility of these consequences (2 GT CO_2, 60,000 deaths) on the individuals that implement and promote such decisions

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Environmental and health impacts of a policy to phase out nuclear power in Sweden

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HIGHLIGHTS

- The Swedish reactor fleet has a remaining potential production of up to 2100 TWh.
- Forced shut down would result in up to 2.1 Gt of additional CO_2 emissions
- 50,000–60,000 energy-related-deaths could be prevented by continued operation.
- A nuclear phase-out would mean a retrograde step for climate, health and economy.

ARTICLE INFO

Article history:
Received 12 December 2014
Received in revised form
18 April 2015
Accepted 21 April 2015

Keywords:
climate change
nuclear power
health impact
electricity production
co2 emissions

ABSTRACT

Nuclear power faces an uncertain future in Sweden. Major political parties, including the Green party of the coalition-government have recently strongly advocated for a policy to decommission the Swedish nuclear fleet prematurely. Here we examine the environmental, health and (to a lesser extent) economic impacts of implementing such a plan. The process has already been started through the early shutdown of the Barsebäck plant. We estimate that the political decision to shut down Barsebäck has resulted in ~2400 avoidable energy-production-related deaths and an increase in global CO_2 emissions of 95 million tonnes to date (October 2014). The Swedish reactor fleet as a whole has reached just past its halfway point of production, and has a remaining potential production of up to 2100 TWh. The reactors have the potential of preventing 1.9–2.1 gigatonnes of future CO_2-emissions if allowed to operate their full lifespans. The potential for future prevention of energy-related-deaths is 50,000–60,000. We estimate an 800 billion SEK (120 billion USD) lower-bound estimate for the lost tax revenue from an early phase-out policy. In sum, the evidence shows that implementing a 'nuclear-free' policy for Sweden (or countries in a similar situation) would constitute a highly retrograde step for climate, health and economic protection.

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Low CO_2 Expansion Summary

- Time it takes to replace all fossil fuelled electricity (+ all currently existing nuclear plants), using regional data extrapolated globally with the reference scenario of:

Swedish nuclear: 23-27 years

French nuclear: 30-38 years

Energiewende: 61-80 years (if at all possible)

Table 5. Time to replace global fossil electricity and current nuclear fleet.

Country	Sweden		France	
Expansion scenario	**Low**	**High**	**Low**	**High**
Time-span	1962–1986	1966–1986	1968–2000	1974–1995
GDP-weighted addition rate (kWh/y/y/1k$-GDP)	12.4	14.7	8.8	11.1
Time to replace global fossil electricity and current nuclear	27.0 years	22.7 years	38.1 years	30.0 years

doi:10.1371/journal.pone.0124074.t005

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RESEARCH ARTICLE

Potential for Worldwide Displacement of Fossil-Fuel Electricity by Nuclear Energy in Three Decades Based on Extrapolation of Regional Deployment Data

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Citation: Qvist SA, Brook BW (2015) Potential for Worldwide Displacement of Fossil-Fuel Electricity by Nuclear Energy in Three Decades Based on

Abstract

There is an ongoing debate about the deployment rates and composition of alternative energy plans that could feasibly displace fossil fuels globally by mid-century, as required to avoid the more extreme impacts of climate change. Here we demonstrate the potential for a large-scale expansion of global nuclear power to replace fossil-fuel electricity production, based on empirical data from the Swedish and French light water reactor programs of the 1960s to 1990s. Analysis of these historical deployments show that if the world built nuclear power at no more than the per capita rate of these exemplar nations during their national expansion, then coal- and gas-fired electricity could be replaced worldwide in less than a de-

Summary

1. Shutting down existing nuclear power ahead of time is **bad for the climate**, regardless of what it is "*replaced*" by
2. Prematurely decommissioning the Swedish nuclear plants (as is currently being done) *will* cause up to 2 GT of CO_2 emissions and up to 60.000 energy related deaths
3. Nuclear power has expanded **many times** faster than any renewable program, including the Energiewende
4. Intermittent power does not replace baseload
5. The world has little chance in tackling global warming, air pollution, resource exhaustion and ocean acidification without the use of **new** nuclear power