

Why We Need Nuclear Power: The Environmental Case

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WHY WE NEED NUCLEAR POWER

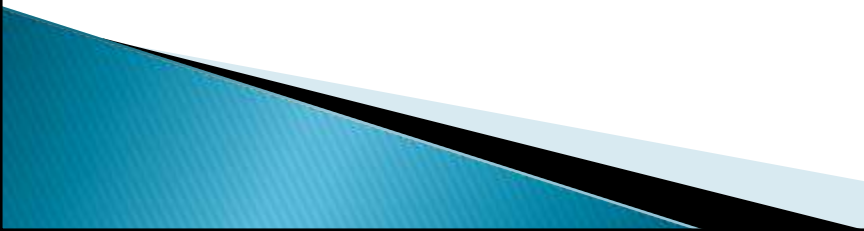
THE ENVIRONMENTAL CASE



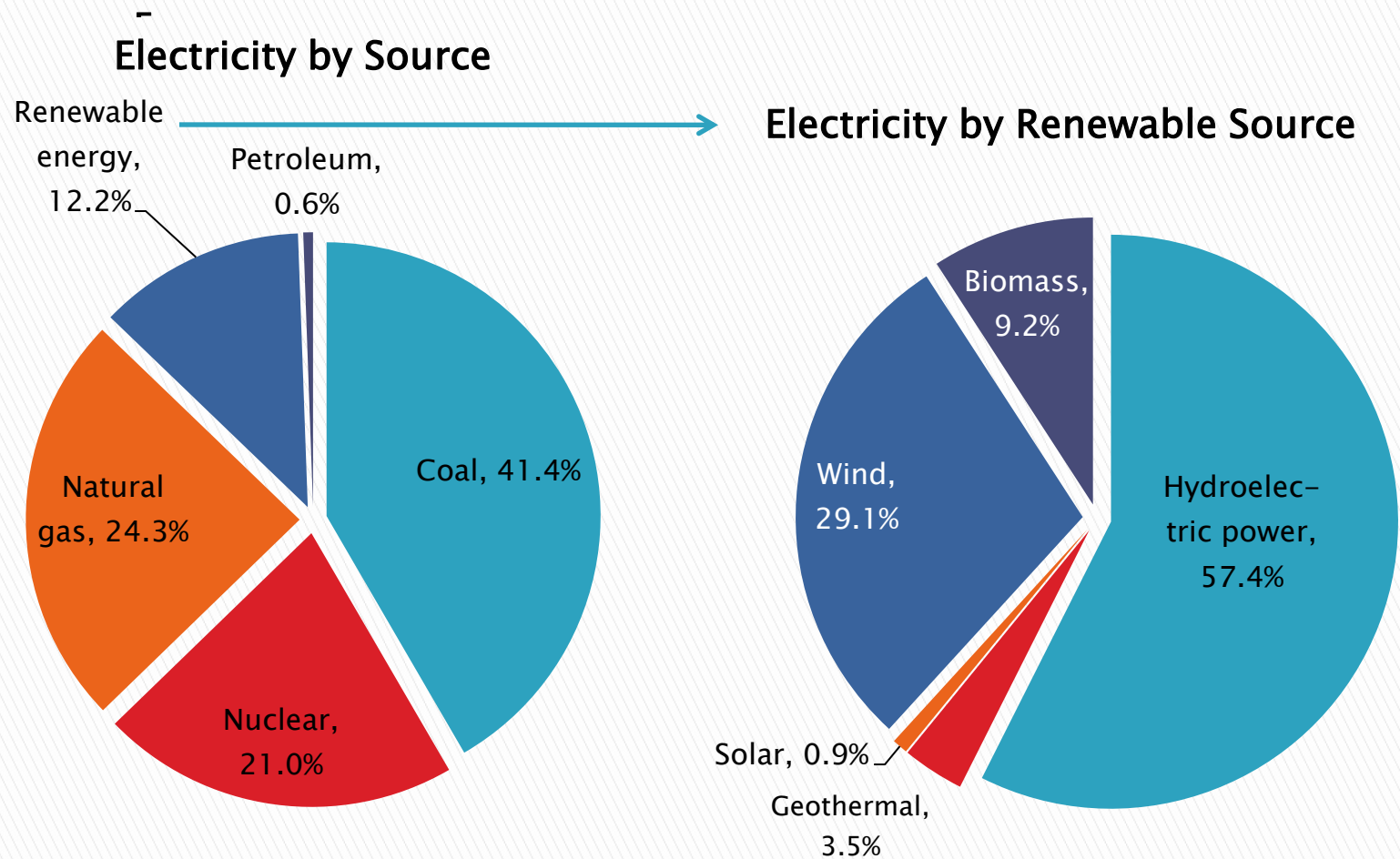
Book signing at
Barnes & Noble
Apr 1, 6–8 pm

Whyweneednuclearpower.com

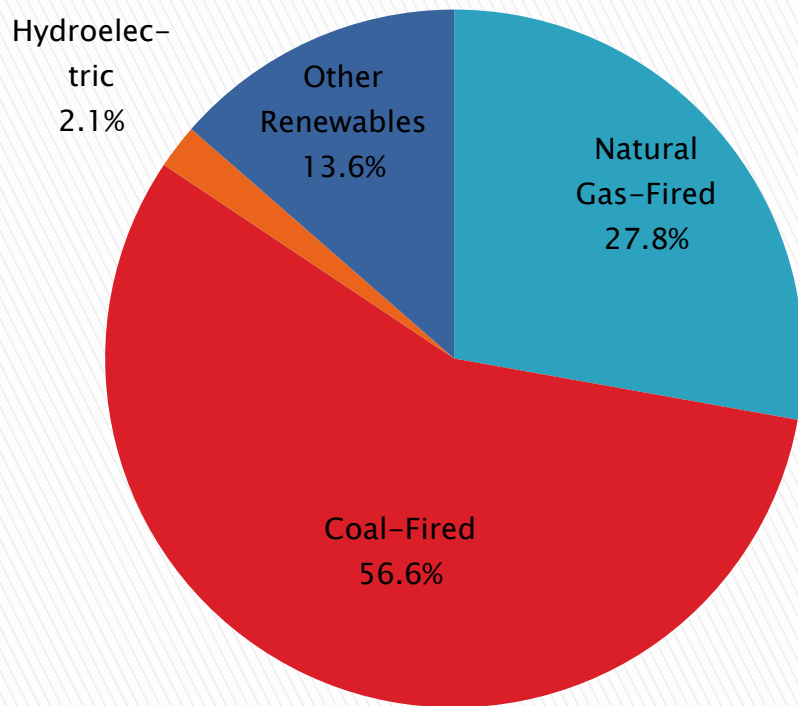
Why we need nuclear power

- ▶ Baseload electricity needed
 - Renewable energy does not provide this
 - ▶ Low carbon dioxide emissions
 - Problem of global warming from CO₂
 - ▶ Reduce dependence on coal
 - Major source of CO₂
 - Environmental problems with mining
 - Deaths from accidents and air pollution
 - ▶ Concerns about natural gas and fracking
 - ▶ Nuclear power can safely wean us off of coal
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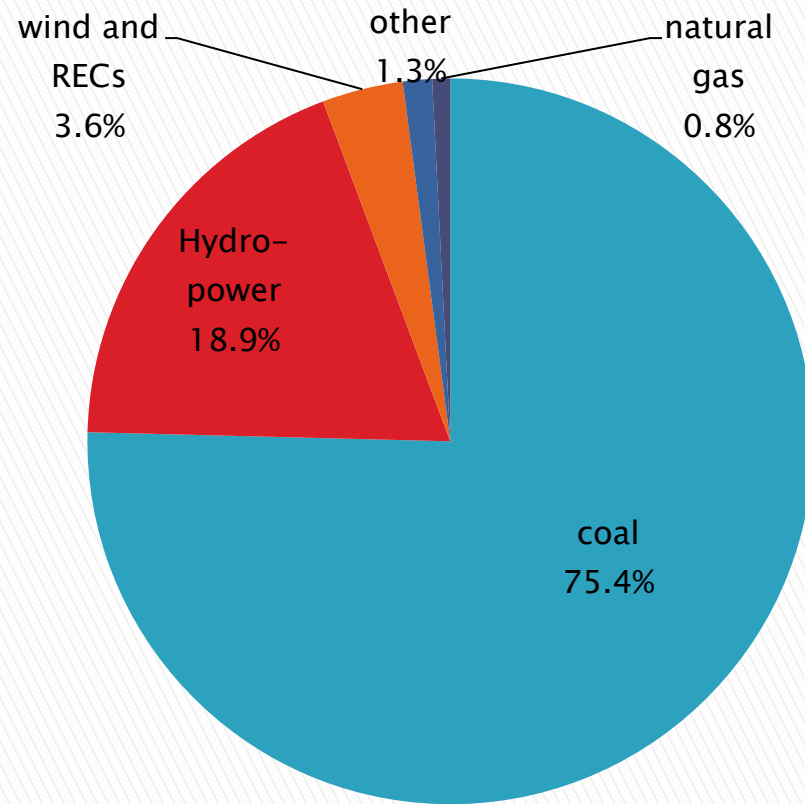
67% of U.S. Electricity Generation Produces CO₂ -- Nuclear Power Does Not



It is worse in Colorado and Fort Collins



Colorado Electricity by Source – EIA 2013



Fort Collins Electricity by Source – PRPA 2013

CO₂ emissions by power source

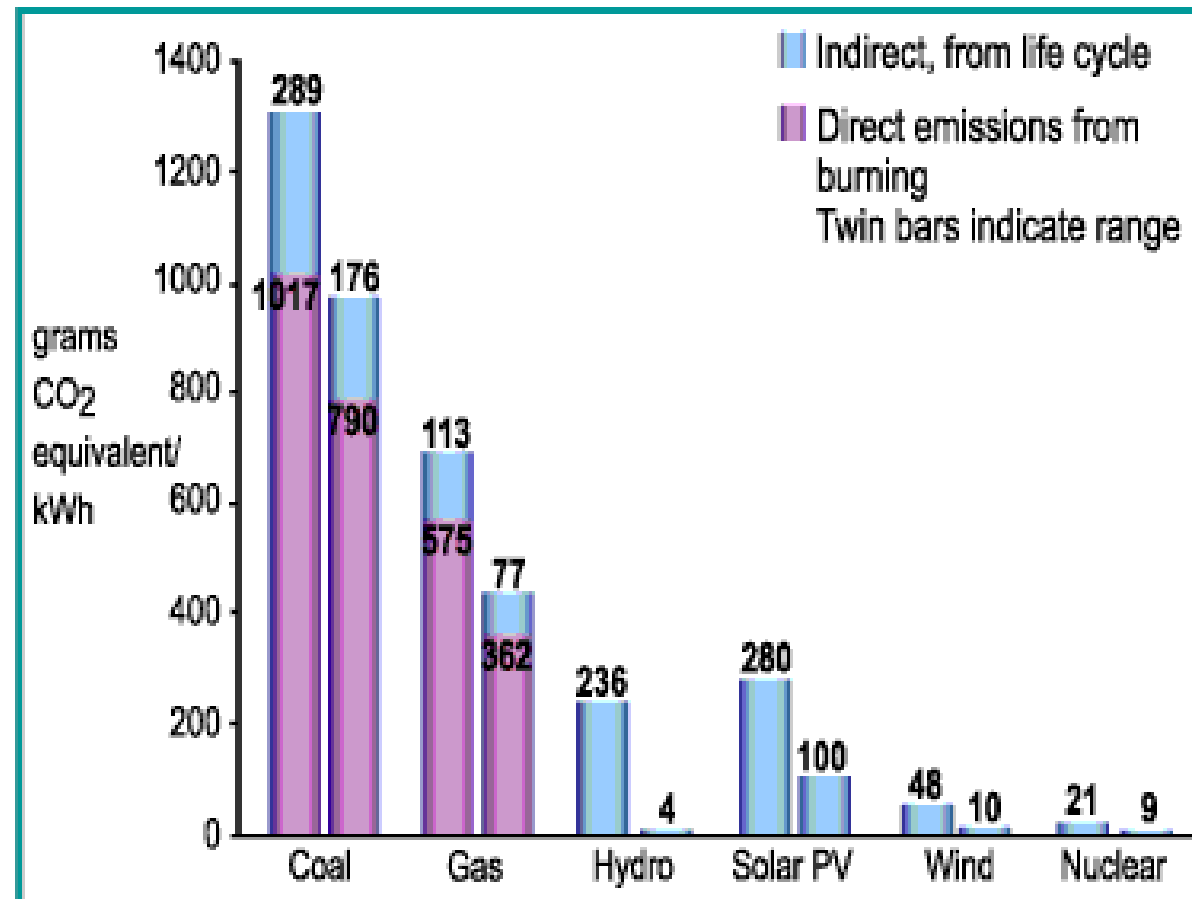
▶ Energy-related CO₂ emissions (2011)

- US: 5.5
- China: 8.7 Gt
- World: 32.6 Gt

▶ Coal CO₂ emissions

- US: 1.9 Gt
- China: 7.2 Gt
- World: 14.4 Gt

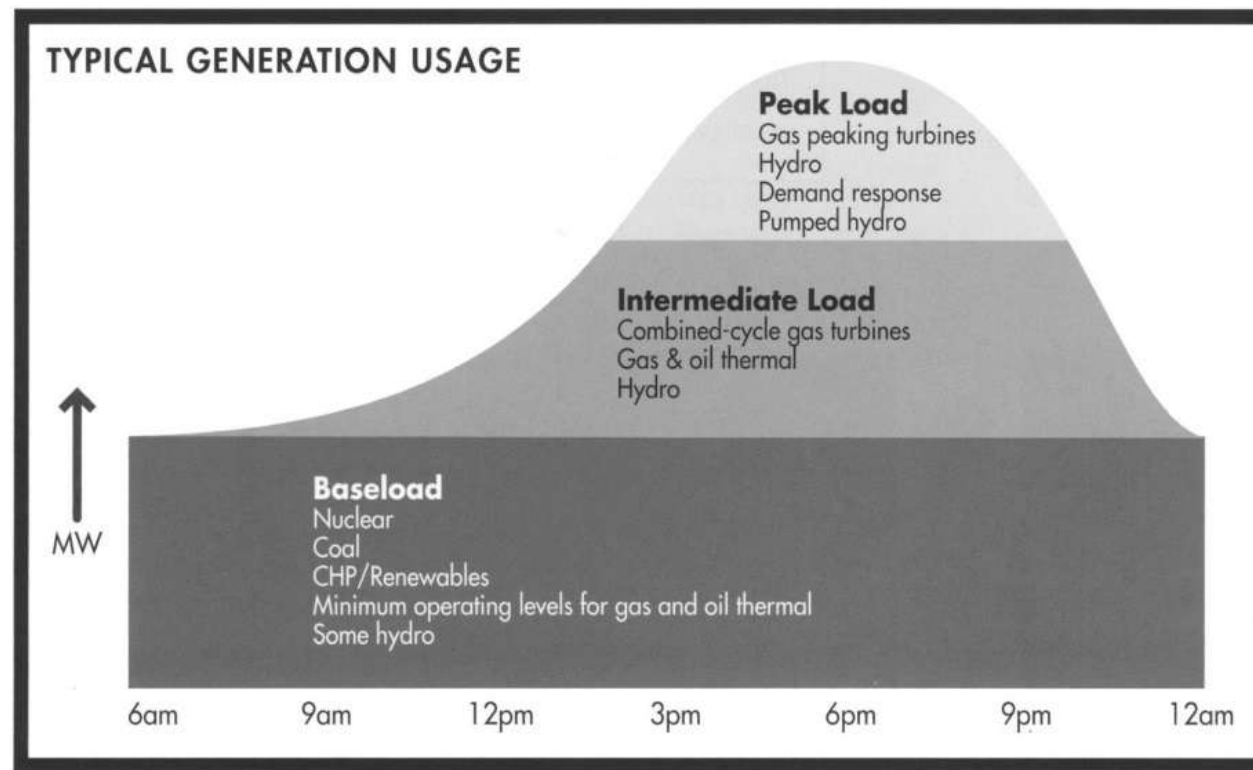
Data from EIA



Source: IAEA 2000

Solar and wind can't replace coal but nuclear can

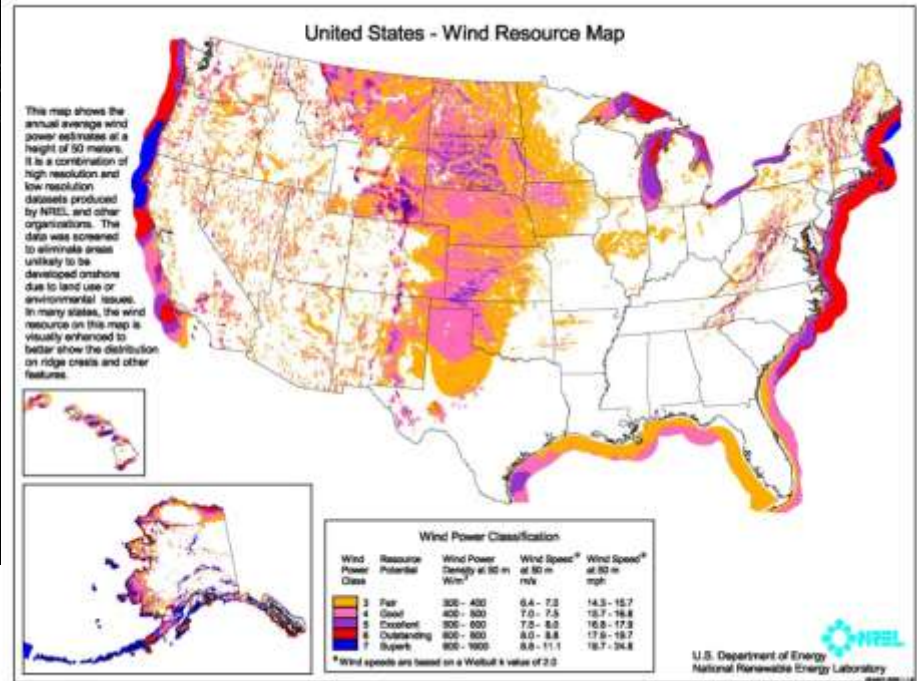
- ▶ Coal provides baseload power
 - Needed 24 hours a day
- ▶ Nuclear power also provides baseload
 - It could be increased to remove need for coal
- ▶ Wind and solar can only contribute to intermediate and peak load
 - Too intermittent and unreliable for baseload



Problems with wind energy

- ▶ Location
 - Best in Midwest and offshore
 - Not where most people live
 - Need transmission lines
- ▶ Intermittency
 - Capacity factor 27% in 2010
 - EIA projects 34% by 2018
 - Needs backup power
- ▶ Footprint is huge
 - About 500 sq mi wind farm to generate same energy as 1 average nuclear power plant
 - Visual impact
 - Road infrastructure
- ▶ Doesn't provide baseload power
- ▶ Provides 4% of electricity in US

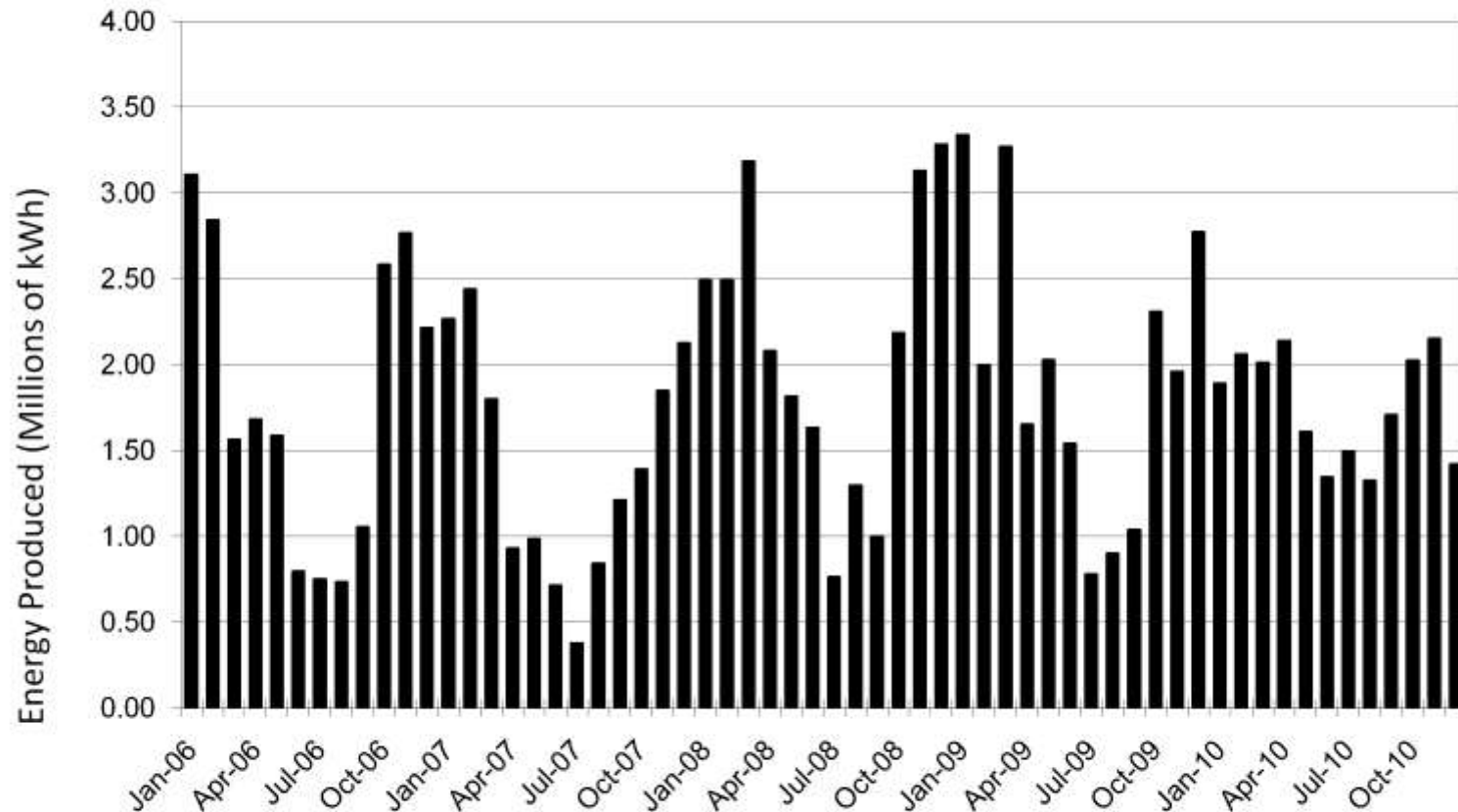
Wind power: location



Where people live

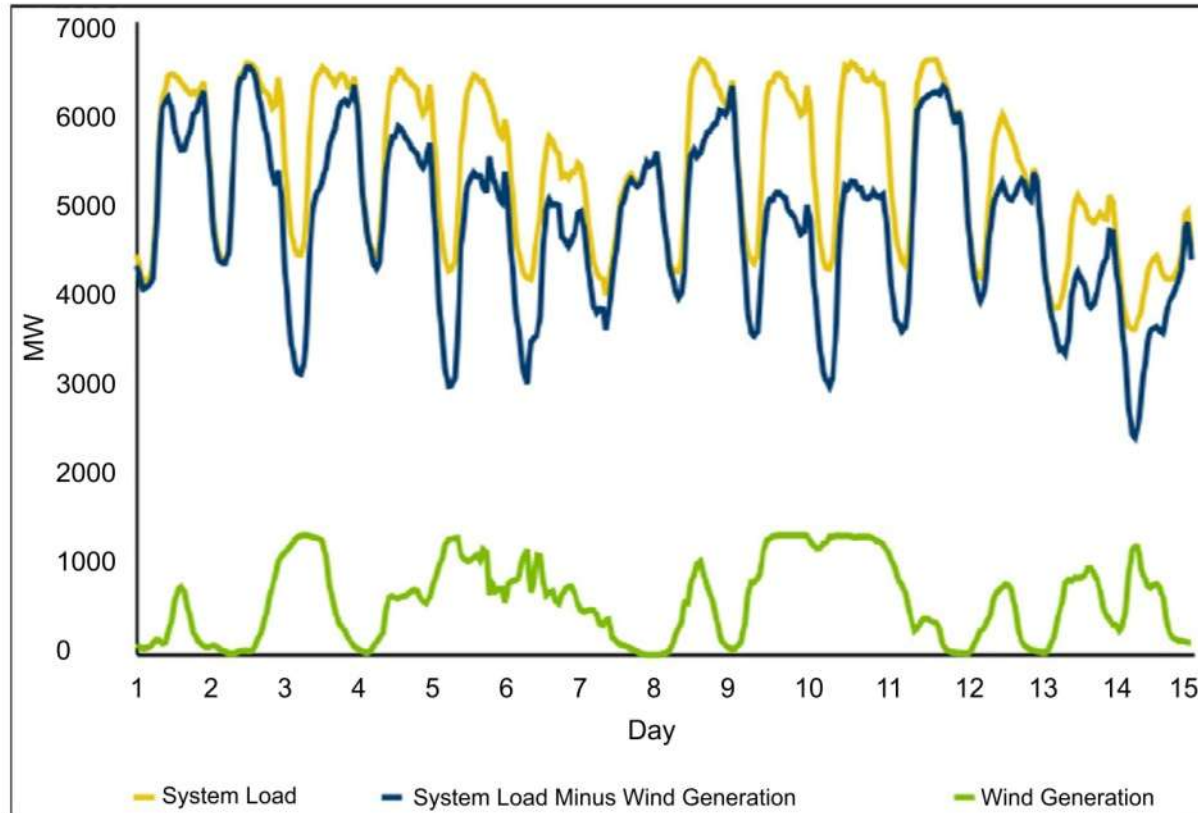
Where the wind blows

Wind power: intermittency



Wyoming – PRPA; Wind blows mostly in winter
Rated at 6 MWh/mo

Wind power: intermittency

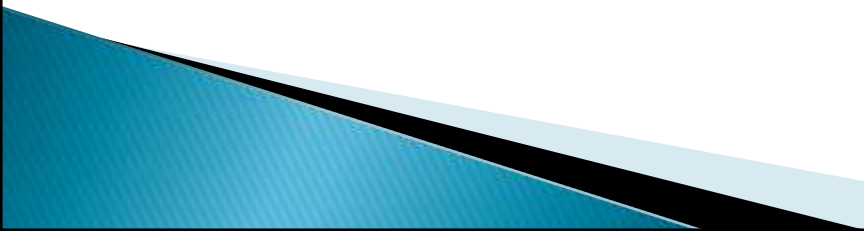


Minnesota Spring 2010; Hourly wind output vs load
Source: DOE

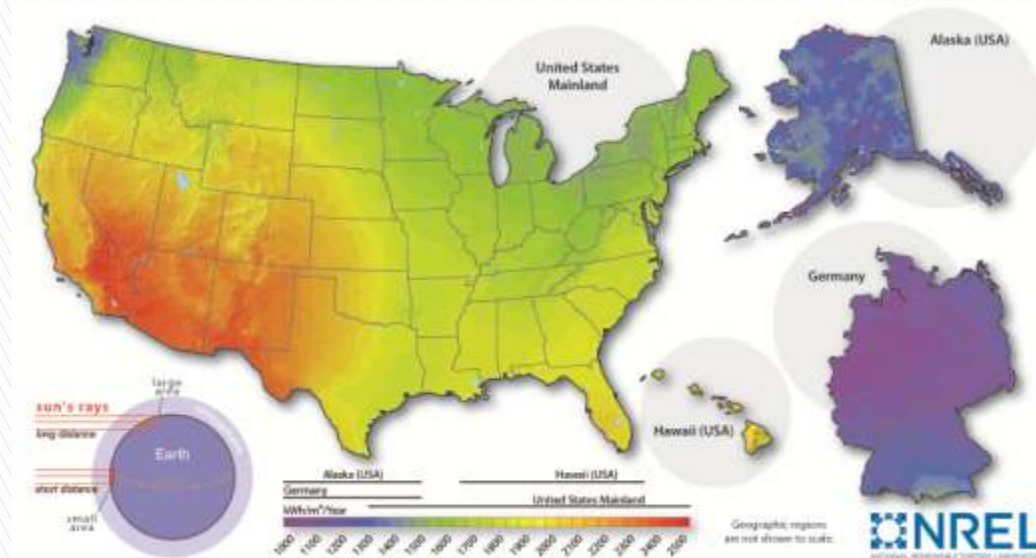
Wind power: footprint



Problems with solar energy

- ▶ Location
 - Best in Southwest
 - Not where most people live
 - Need transmission lines
 - ▶ Intermittency
 - Varies through day
 - Clouds, snow, etc
 - Efficiency about 12%
 - Needs backup power
 - ▶ Footprint is huge
 - About 50 sq mi solar farm to generate same energy as 1 average nuclear power plant
 - Environmental impact
 - ▶ Doesn't provide baseload power
 - ▶ Provides 0.1% of US electricity
- 

Solar power: location



Where people live

Where the sun shines

Solar power installations

San Luis Valley



CSU Solar Village



My grid-tie system



My cabin



Deaths from Coal vs Nuclear

- ▶ Coal mining¹
 - >2,000/yr 1900–1930
 - This happens currently in China
 - >1,000/yr 1931–1947
 - Average 451 /yr in 1950s
 - Average 142 /yr in 1970s
 - Average 43 /yr in 1990s
 - Average 33 /yr in 2000s
 - Black lung/lung cancer/respiratory disease
 - thousands per year in US
 - Hundreds of thousands per year in China
- ▶ US nuclear industry over 40+ years
 - **None**

Coal: environmental damage



West Virginia: mountaintop removal and valley fill



Wyoming: Powder River Basin

Natural Gas

▶ Advantages

- Half the CO₂ of coal (maybe)
 - Depends on fugitive emissions
- US has a plentiful supply
- Can replace coal plants
- Cheap but volatile

▶ Disadvantages

- Methane from leakage
 - 25 times greater GHG than CO₂
- Fracking
 - Potential air and water issues
- Used in all sectors of energy economy
 - Competition for resource
- Deaths from accidents

Advantages of nuclear power

- ▶ Replace coal for baseload power
- ▶ No carbon dioxide emissions
- ▶ Build them where energy needed
 - Small footprint – about 1 / 3 sq mile
- ▶ Run 24 / 7 with > 90% capacity factor
- ▶ Lots of power – average about 1,000 MWe
- ▶ Proven technology
 - Boiling water reactors
 - Pressurized water reactors
- ▶ New designs even safer for future
 - Cooling for several days without power
 - Small Modular Reactors

Nuclear power reactors

Country	% electricity	Reactors operable	Under construction	Planned/proposed
USA	19.0	100	5	22
France	74.8	58	1	2
Japan	2.1*	48	3	12
Russia	17.8	33	10	49
China	2.0	20	28	176
Canada	15.3	19	0	5
India	3.6	21	6	57
World	11	434	70	483

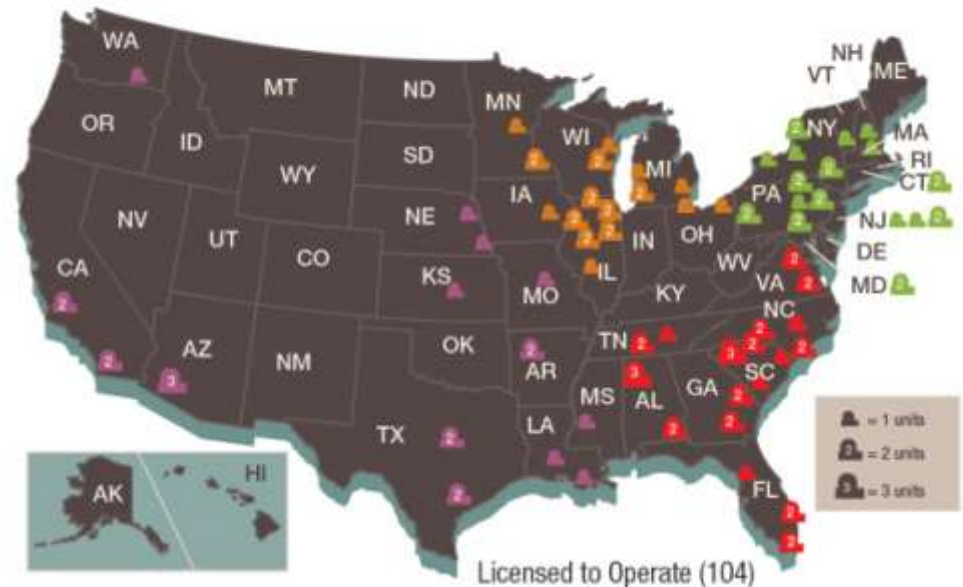
*Japan has temporarily shut down their reactors

Data from World Nuclear Association 2/1/14

Nuclear power: location



U.S. Operating Commercial Nuclear Power Reactors



Where people live

Where reactors are

Nuclear power reactors



Three Mile Island (PA)



Wolf Creek (KS)

Risks of nuclear power

- ▶ Radiation from nuclear fuel cycle
 - Very small <0.1 mSv
- ▶ Nuclear waste
 - On-site storage
 - Cooling pools
 - Dry cask storage
 - Geological disposal
 - Yucca mountain?
 - Recycle used fuel
 - France, Russia, Japan, Germany, UK do it
 - Reuse Pu in MOX fuel
- ▶ Major accidents
 - Chernobyl
 - only accident to cause loss of life
 - 31 immediate deaths
 - 19 more by 2004 from uncertain causes
 - 15 kids from thyroid cancer
 - 4,000 over a lifetime
 - Fukushima
 - due to tsunami that killed over 19,000 people
 - A few people may ultimately die of cancer
- ▶ Over 14,500 reactor years of operation

Can we stop using coal to make electricity and reduce CO₂?

- ▶ 600 coal-fired plants produce 16 quads (Quadrillion BTUs) of energy
 - produce 1.7 Gt CO₂
- ▶ 100 nuclear reactors produce 8.0 quads
- ▶ 200 additional reactors could replace the coal-fired plants
 - Even fewer since new reactors are about 1200 MWe compared to current 950 MWe average
- ▶ This would reduce environmental damage from mining, global warming from reduced CO₂ and loss of life from mining accidents

What I believe we can and should do to mitigate climate change

- ▶ At least double nuclear power capacity to reduce/eliminate coal fired plants
 - ▶ Increase fuel efficiency of cars to 55 mpg average (new CAFE standards)
 - Increase hybrids and electric vehicles
 - Need more electricity to power EVs
 - Hydrogen cars???
 - ▶ Get 20% of electricity from wind and solar
 - ▶ Increase energy efficiency in houses, factories, and public buildings
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