Energy and Society

Jan Osička

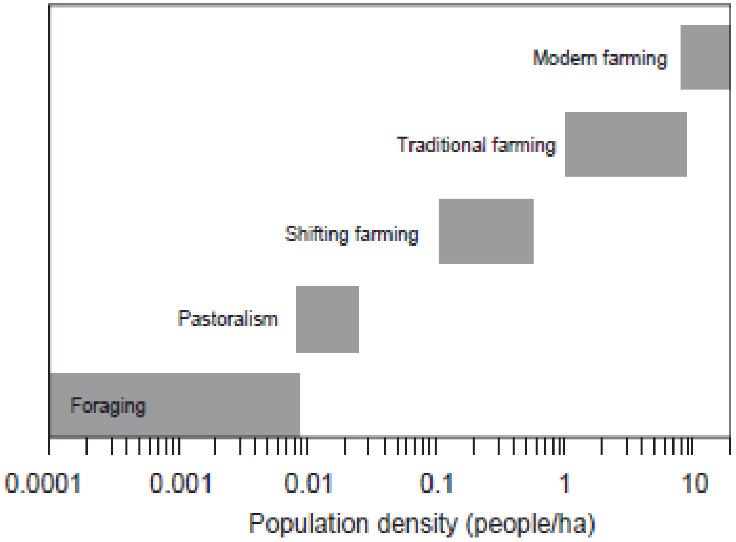
Energy-intensive society: how did we get there?

Foraging society

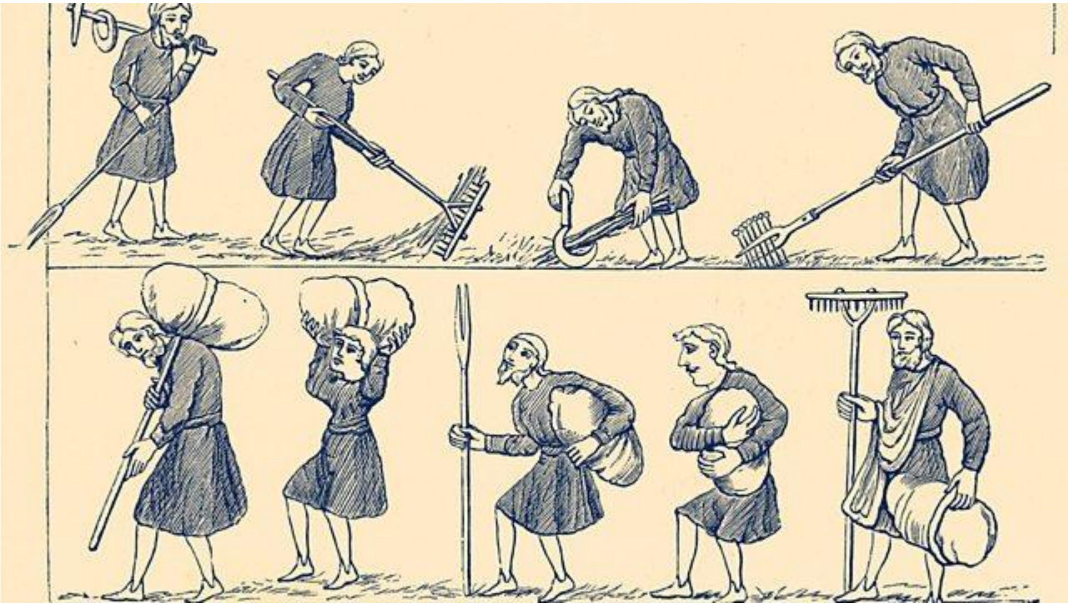
- Human body and exosomatic sources of power - fire, body extensions (bows)
- Energy return on investment (EROI) up to 40, usually around 3, often around 1.
- Very low population density (0,1 person/sq. km)

Agricultural society

- Greater population density (20-30 persons/sq. km)
- First exosomatic sources of power:
  - Oxes (200-500 W)
  - Charcoal (29 MJ/kg, no smoke)
- Metallurgy: low efficiency, high energy intensity (until 1750)



Progress in the Middle Ages: prime movers

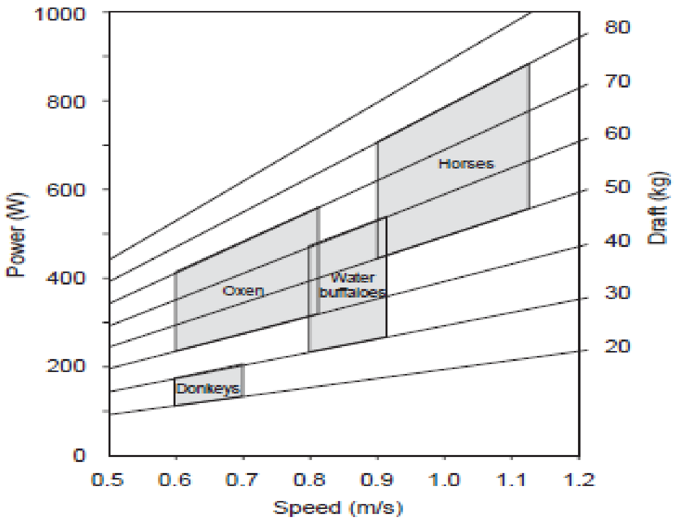


Organic prime movers still dominant

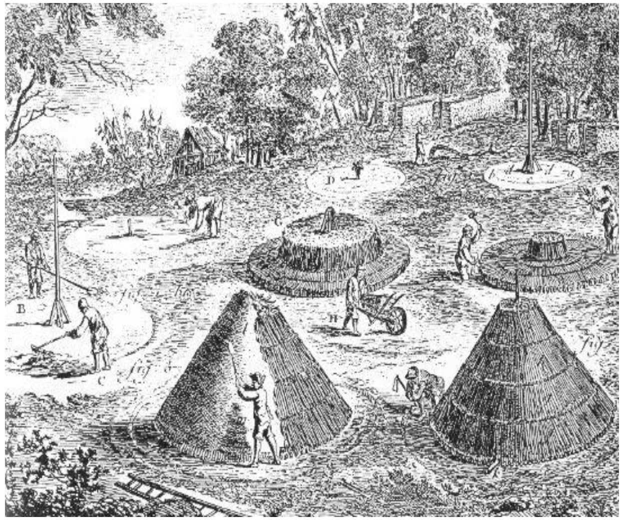
- Increased efficiency in energy transformation (treadwheels, horseshoes, fodder, breeding)

Non-organic prime movers

- Watermills (England, 11th century)
- Wind power: sails (+ compass, heavy cannons, rear stear = colonization)



Progress in the Middle Ages: fuel scarcity

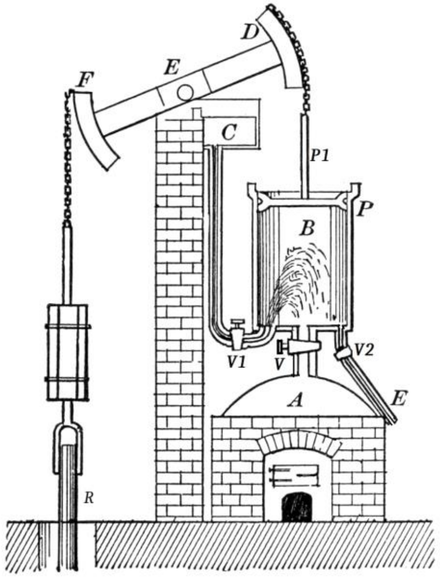



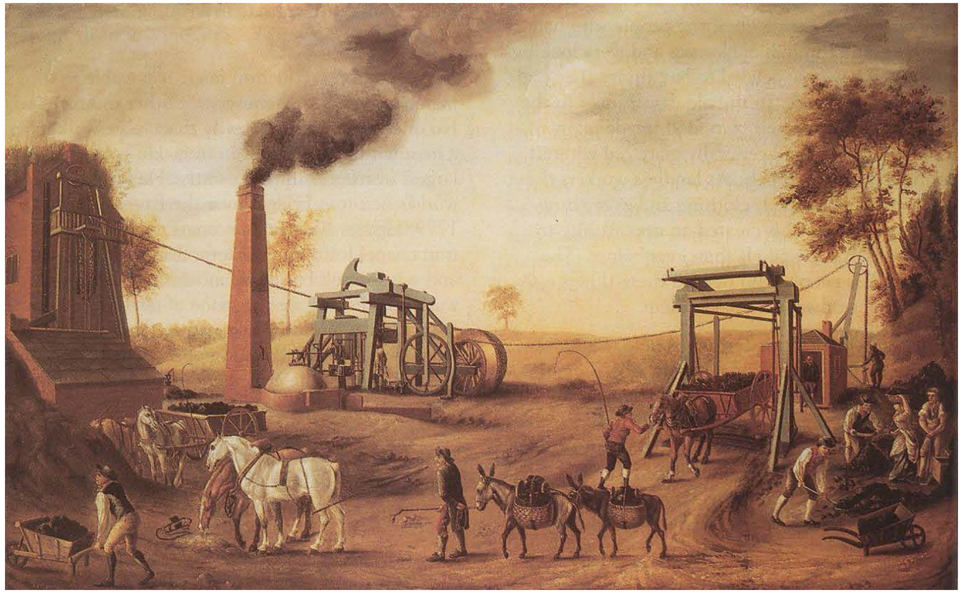

Early 18th century England

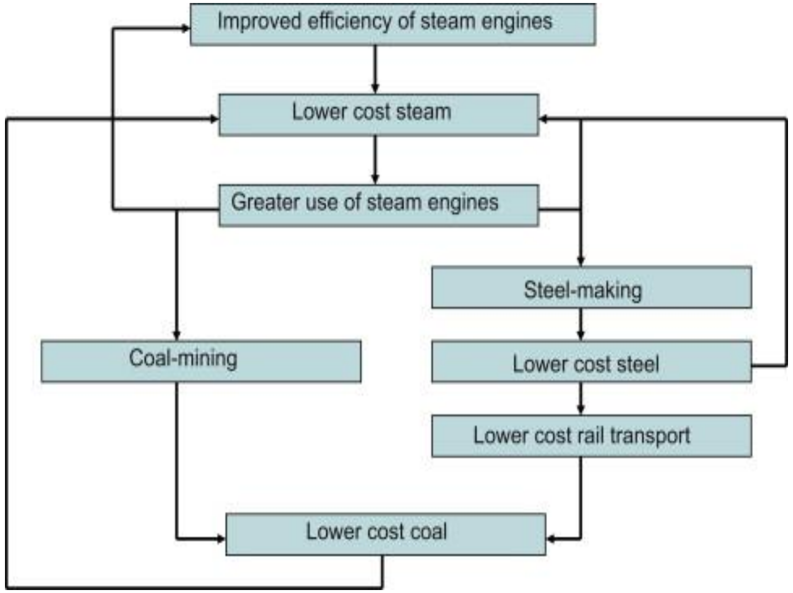
- Average furnace
  - 300 tons of iron per year
  - 12,000 tons of wood
  - 20 square km of forest

- Total production: 20,000 tons of iron (1,100 km^2 of forest)
- Total production in early 19th century: 1,000,000 tons of iron

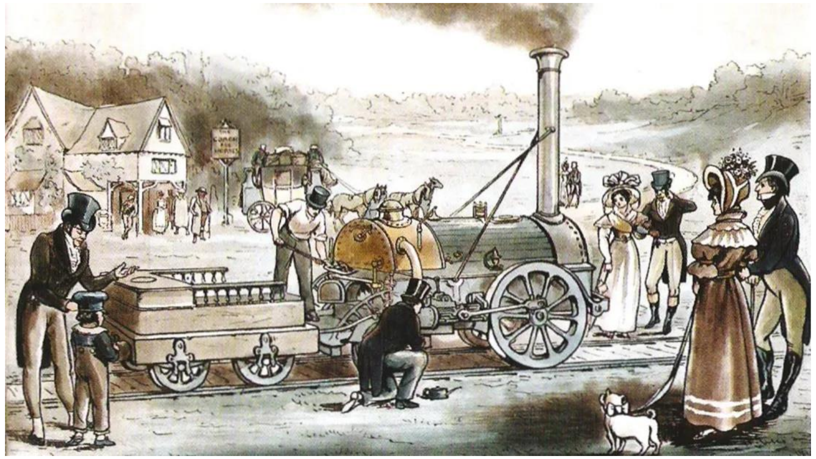

Towards modernity: steam engine



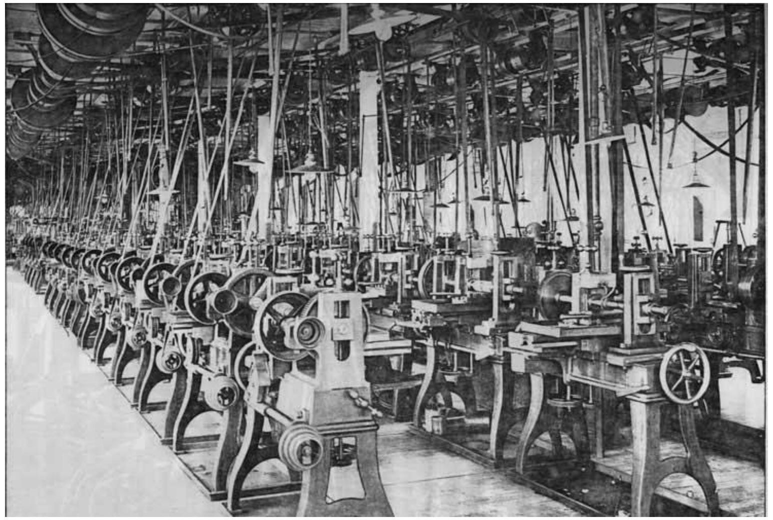
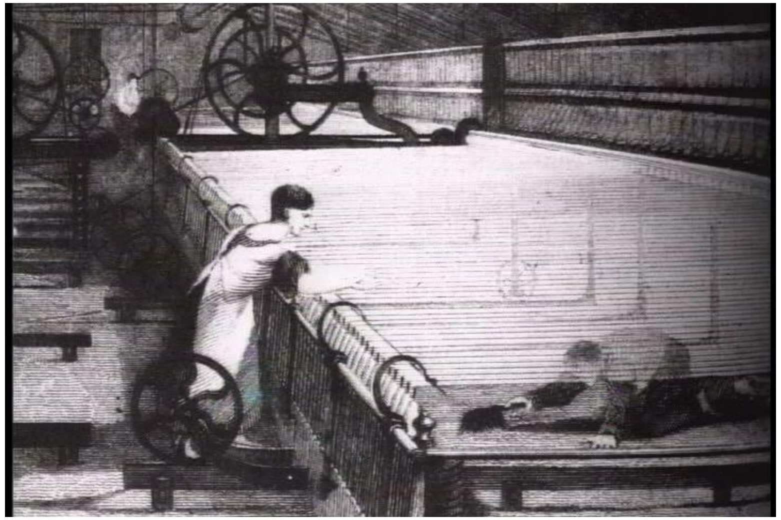




- Early steam engine (Newcomen): 20 kW, efficiency 5%
- Coal – steam – steel positive feedback
- Later (19th century): inland transport revolution

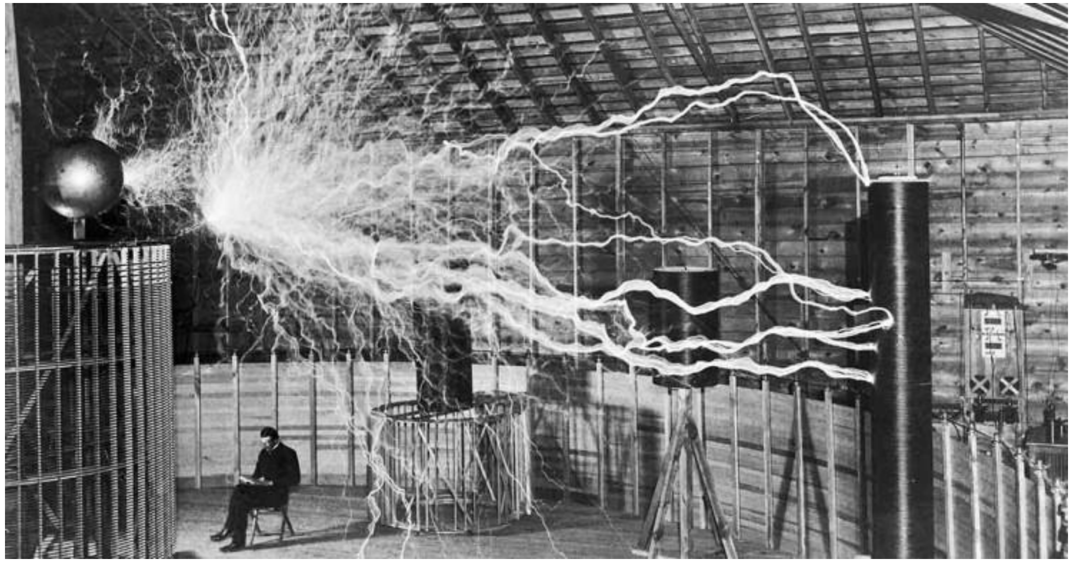


Towards modernity: industrial revolution

- Powered by watermills and later steam
- Europe 1800-1950: Five distinct prime movers: humans, animals, watermills/turbines, windmills, steam engines
- USA 1870: mechanical power outweighs organic power
- North Sea 1900: installed capacity in windmills: 100 MW

Towards modernity: 1880-1900



- T. A. Edison: the basics of electricity production and use
- G. Westinghouse and N. Tesla: alternating current
- Ch. Parsons: steam turbine
- W. Stanley: transformer
- N. Tesla: electric motor

- USA 1930s: 80% of all mechanical power electrified
- Profound change in work and personal life

- G. Daimler: spark ignition engine
- W. Maybach: carburator
- K. Benz: electrical ignition
- R. Diesel: compression ignition engine

- Three waves of automobile dissemination
- Aviation: 1904: the Wright brothers, 1969 Boeing 747, 1969: Apollo 11


PAN AM

Energy-intensive society

Energy-intensive society

Prime Mover	Sustained Power (W)
Working child	30
Small woman	60
Strong man	100
Donkey	150
Small ox	300
Typical horse	600
Heavy horse	800
Early small tractor (1920)	10,000
Ford's Model T (1908)	15,000
Typical tractor (1950)	30,000
Honda Civic (2000)	79,000
Large tractor (2000)	225,000
Large diesel engine (1917)	400,000
Large marine diesel engine (1960)	30,000,000
Four gas turbines of Boeing 747 (1970)	60,000,000

- Mechanization of agriculture and industry

- Last 10,000 years:
  - Maximum power of the prime movers has increased 15,000,000x
  - 99% of this change occurred in 20th century

Energy-intensive society

- Increased quality of life

- Increased inequality
  - 10% consumes 40% of all primary energy
  - 50% consumes 10% of all primary energy

- Anthropocene

Conclusions

- Development stages reflect the power, efficiency, and flexibility of employed prime movers
- Harnessing more energy leads to greater complexity of society
- Maintaining the level of complexity requires energy

Now, about the course..

What will we be doing here?

- Study and discuss the development of the World energy system since 1945.
- Learn about the roots of the contemporary energy policies.
- Identify and analyze the most influential trends in the past and present energy system.
- Discuss the future of energy.

Who will be guiding you through the course?

Jan Osička

Filip Černoch

2009 Istanbul Bilgi University

- Energy markets
- Renewable energy
- Cross-border effects of energy policies

2016 Deutsche Gesellschaft für Auswärtige Politik

2016 Energy advisor to PM Sobotka

- Energy policy in the EU
- Energy transitions
- The regulation behind Energiewende

Masaryk University Center for Energy Studies

Founded by Břetislav Dančák in 2009

Dpt. of International Relations and European Studies: 8 full-time researchers

Multidisciplinary research platform dealing with energy

- Social dimension of energy transactions (public participation, local opposition, energy poverty)
- Energy geopolitics (Russia, pipelines, power)
- Energy transition (renewable energy, decarbonization)

Center for Energy Studies

Energy research and education platform of the Faculty of Social Studies, Masaryk University, the Czech Republic.

Mezinárodní vztahy a energetická bezpečnost

(Czech language masters degree)

Energy Policy Studies

(English language masters degree)

Summer school

(In cooperation with Energy Community)

Energy research

(Research areas and activities)

www.energy.fss.muni.cz

Modern energy system:
the case of nuclear energy

The afterwar period - changes introduced during/after the war

Regimes, institutions and economy

- War economy – nationalization of resources and supply chains (US/UK)
- US turns net energy importer – further pressure on relations with producing countries

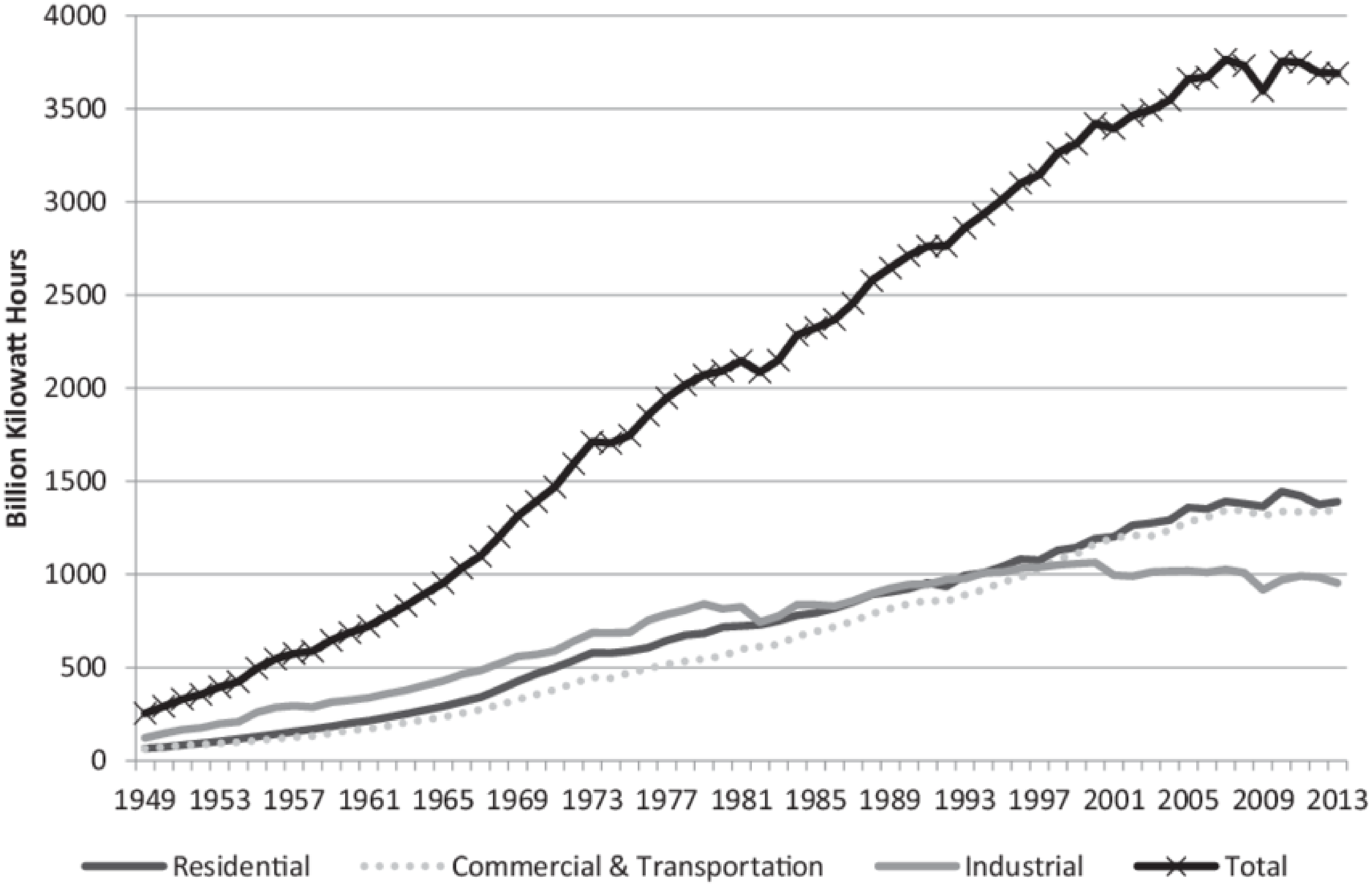
Technological advancement

- ICT – radar, remote control, guiding systems, electrical computation, network communication
- Transportation – ICS-based mobility, jet engine-based aviation
- Rocket science – space program

- Chemical engineering – plastics (substitutes for rubber and glass)
- Piping/welding – oil and gas transfers
- Nuclear energy

The afterwar period

Electricity consumption in the U.S.



Consolidating the power industry: the business model

The “Grow and build“ strategy
(technological progress + cost/price decline)

- Promote electricity usage
- Build bigger and more efficient plants
- Bring down the costs and sell more electricity
- Promote further electricity usage
- …

Year	Rated power (MW)	Thermal efficiency (%)	Price (USD1992/kWh)
1892		2.5	4.00
1907	12		1.56
1927	110	20	0.55
1947			0.19
1967	1,000	40	0.09

The consolidation of nuclear industry in the U. S.

“The energy produced by breaking down the atom is a very poor kind of thing. Anyone who expects a source of power from the transformations of these atoms is talking moonshine.”

Lord Ernest Rutherford, 1933.

“It is not too much to expect that our children will enjoy in their homes [nuclear generated] electrical energy too cheap to meter.”

Lewis Strauss, Chairman, US Atomic Energy Commission, 1954.

„The failure of the U.S. nuclear power program ranks as the largest managerial disaster in business history, a disaster on a monumental scale … only the blind, or the biased, can now think that the money has been well spent. It is a defeat for the U.S. consumer and for the competitiveness of U.S. industry, for the utilities that undertook the program and for the private enterprise system that made it possible.“

Forbes cover story “Nuclear Follies“, February 11, 1985

The origins

The Manhattan project (1942-1946)

The experimental breeder reactor (1951)

Atoms for Peace (1953)

Atomic Energy Act of 1954

- Regulatory oversight over nuclear energy assigned to the Atomic Energy Commission (AEC)

Commercialization of nuclear energy

- AEC‘s role: „*To ensure public health and safety from the hazards of nuclear power without imposing excessive requirements that would inhibit the growth of the industry*“ (NRC 2017)

- Insufficiently rigorous regulations in several important areas, including radiation protection standards, reactor safety, plant siting, and environmental protection

Commercialization of nuclear energy

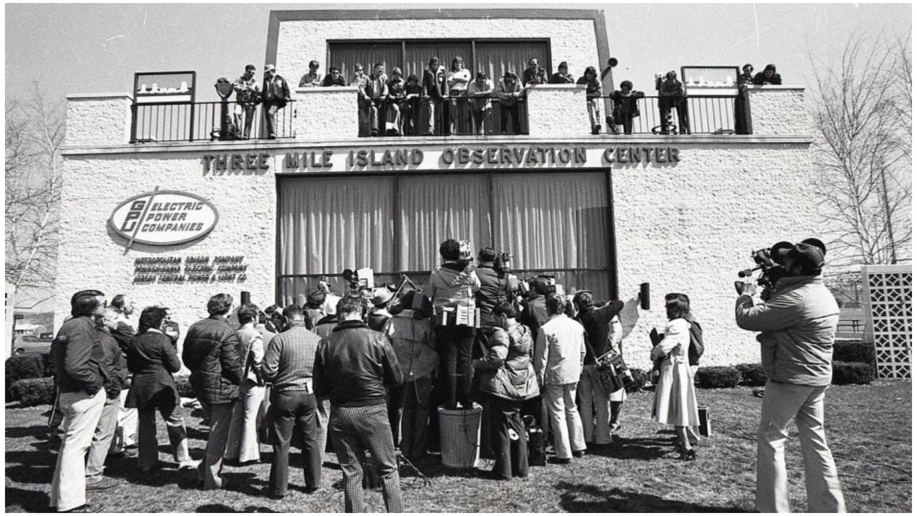
- Rapid increase in power output
  - 1953-1962: below 300 MW
  - 1965: average 660 MW
  - 1970: average above 1,000 MW

- Upscaling perhaps too fast to facilitate learning

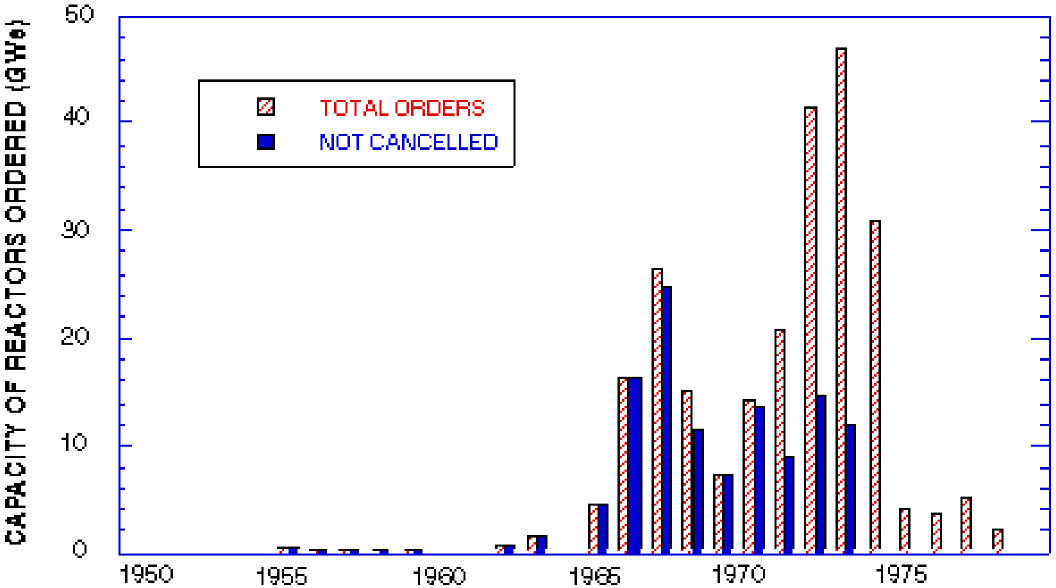
- Multiple manufacturers (Westinghouse, Argonne National Laboratory, General Electrics, BWXT,…) => multiple reactor designs and sub-designs (each unit a prototype)

=> Economy of scale has not been achieved

1970s: industry in crisis



- Electricity demand increases with a slower pace
- Costs of nuclear power increase
- Political and local opposition towards nuclear



Shoreham NPP (Long Island, USA)

- Announced in 1965 by Long Island Light Company (LILCO)
- Expected to come on line by 1973 at $65 - $75 million

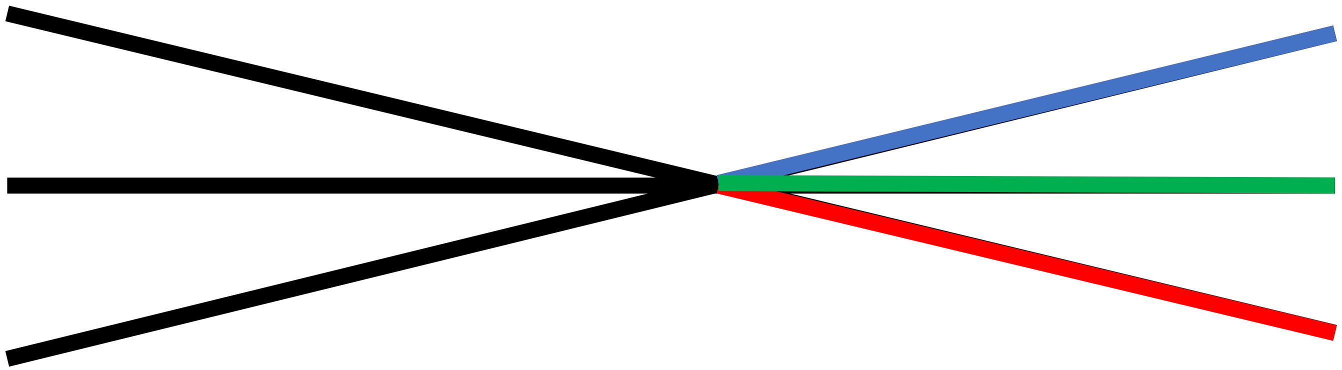
- 1968 LILCO decides to increase the unit‘s size from 540 to 820 MW
  - Cost overrun
  - Construction delay => more time for anti-nuclear movement to spread across Long Island

- 1979 Public opposition intensifies after the Three Mile Island accident => 1983 the county legislature does not approve the plant‘s evacuation plans
  - Costs reach $2 bn (low productivity and design changes ordered by federal regulators)

- 1984 The plant is completed, but does not receive operation license due to the unapproved evacuation plans

- 1994: The plant is fully decommissioned, the total costs reach $6 billion (covered by the LI consumers)

Discussion: path dependencies and critical junctures



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