Energy systems and their transition

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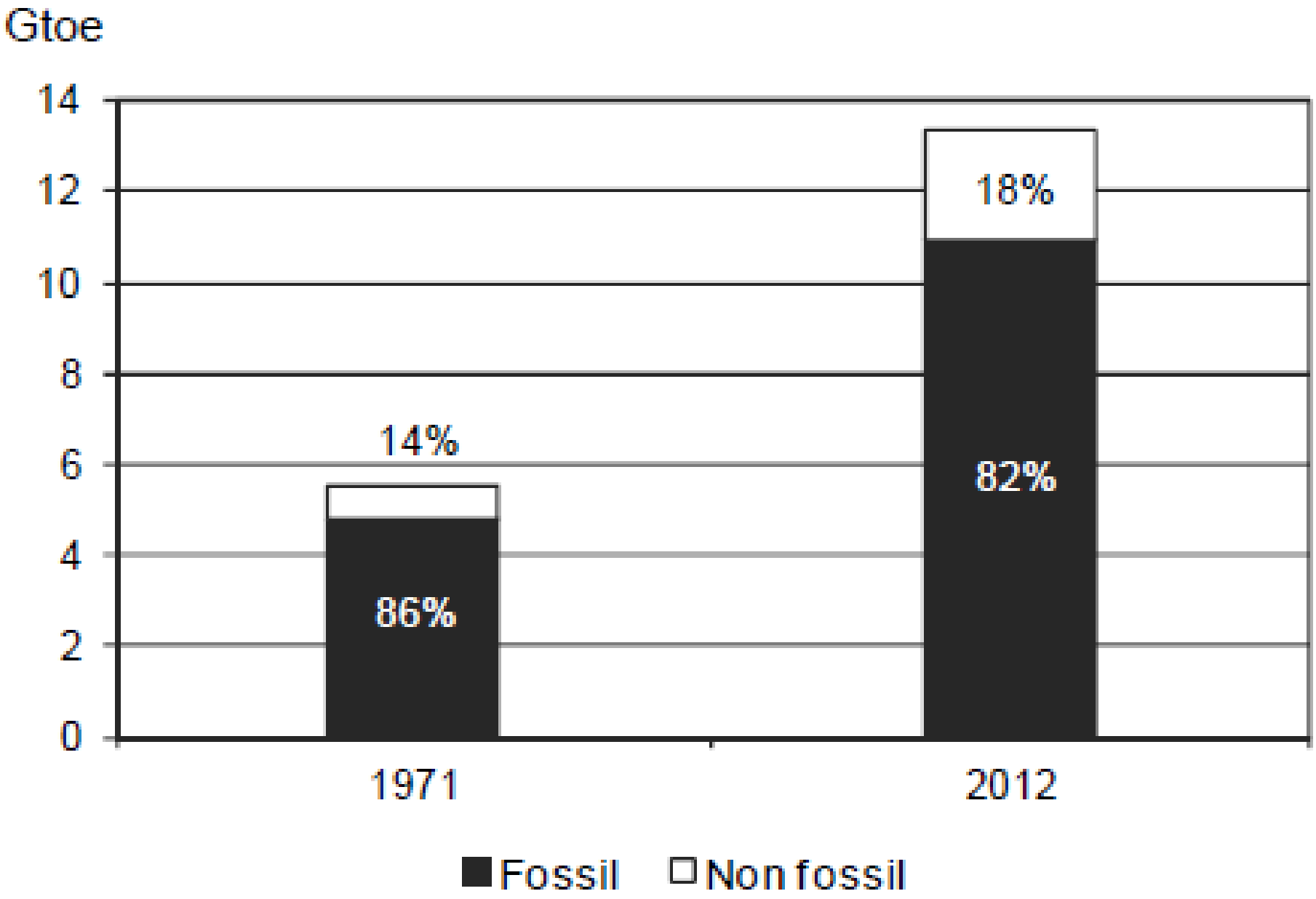
Energy transition to low-carbon system

- Climate change results from the production and consumption patterns – satisfying consumer´s demands for goods and services through the carbon-based energy technologies and systems.
- Climate change mitigation is based on a switch to more efficient (low or zero-carbon) technologies and sources (RES).

- Why don´t carbon-saving technologies diffuse faster?

World primary energy supply



Theory of technology (energy) transition

Economic argumentation suggests that the optimal technology is selected based on market forces and fully informed, optimizing agents. But this argumentation is incomplete.

1) There are some other factors affecting the people and company´s choices (setting the system).

2) Once some choices are made they determine the future path (changing the system).

Different power production choices of similar countries

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What determines which technology is in use?

- Technically best choices from technologies available?
- But different countries make different choices.

= It is not market decision only, people (individuals, collectives) make choices. Market just coordinate.

1) Technological systems – case of automobile industry

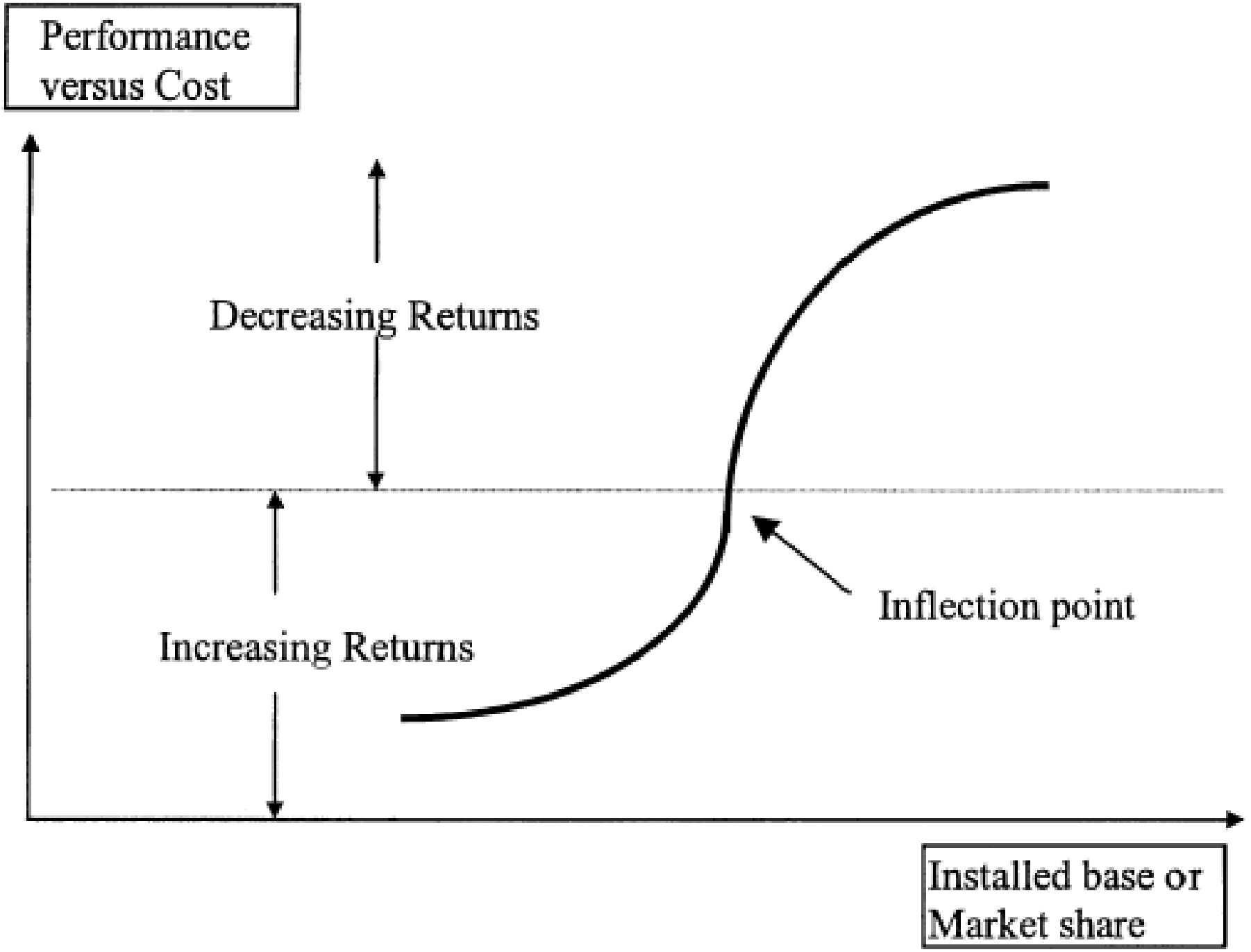
- Beginning of 20.century, competition among steam-, electrict-, gas-powered vehicles to substitute horse and carriage. (noxious, noisy, complicated and dangerous vs cheap gasoline as a by-product from the production of kerosene).
- Than period of increasing returns to scale…locking internal combustion engine (ICE) as the dominant design.
- Producers of other design are reduced – in 1890s, 1900 different firms producing over 3200 different variants of ICE vehicles in USA. In 1920s, a few dozens. By 1955 the Big Three (General Motors, Ford, Chrysler) held 90 % of domestic and 80 % of the global market.

Technological systems

- Surviving oligopolistic firms shifted their focus from product to processes innovation, development of specialized knowledge = forming the basis of a company´s competitive advantage.
- General Motors divided engine development into 22 subsystems (ignition, fuels systems, lubrication etc.). That had lasting impacts on specialised labor and knowledge development.

= firms tend to focus on existing competencies and away from alternatives that could make their present products obsolete.

= capital investment goes preferentially towards projects that reduce production costs and perfect existing product.


Performance versus Cost
Decreasing Returns
Increasing Returns
Inflection point
Installed base or Market share

Technological systems explanation

- Technological system (TS) – inter-related components connected in a network or infrastructure that includes physical, social and informational elements (for example, automobile transportation system).
- Changes in TSs are based on evolutionary framework with the dominant design models.
  - Invention and inovation create several technologial variants.
  - Period of uncertainty – variants compete for performance improvements and market share.
  - One of the variants captures a critical mass of the market and become de facto standard.
- Technologies than can exhibit increasing returns to scale (positive feedback) that accelerate improvements relative to competing variants.

Lock-in of interdependent TSs

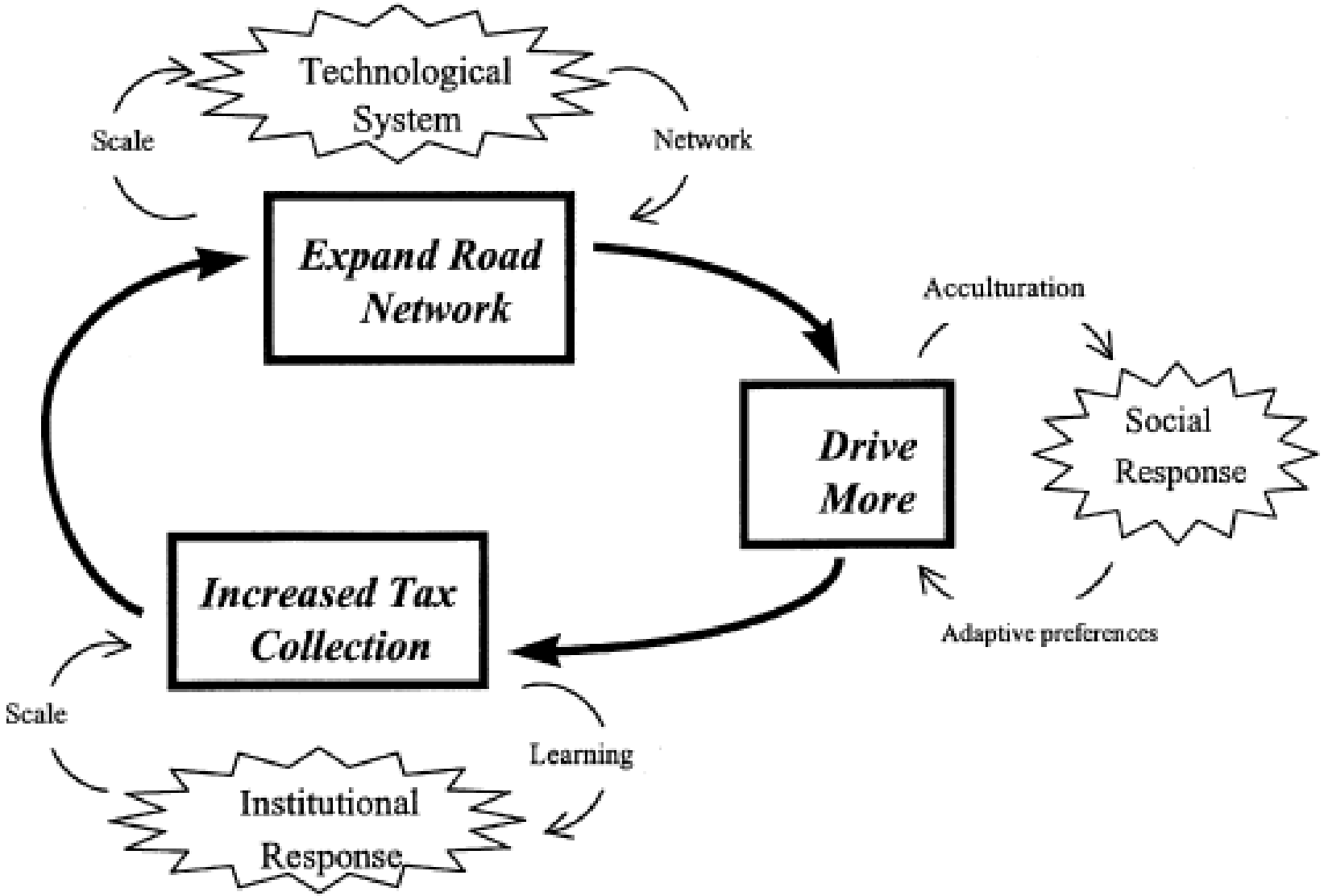
- Network externalities arising from systemic relations among technologies, infrastructures, independent industries and users.
  - Positive externalities – physical and informational networks can become more valuable to users as the grow in size (road network, telephone network).

= the viability of the automobile depends on the development of multiple supporting technologies and industries to create a functional systém.

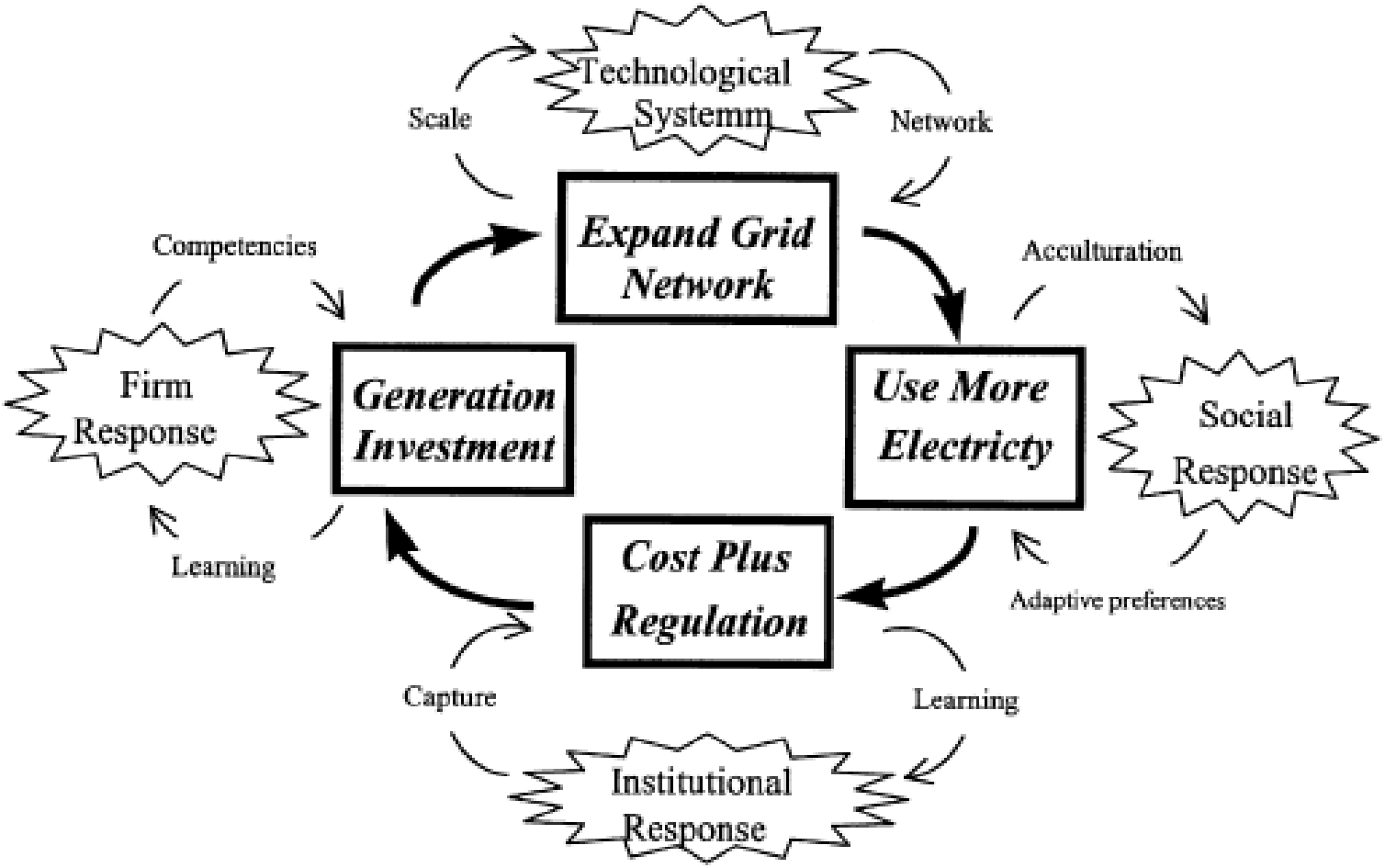
The techno-institutional complex

- TSs and institutions are inter-linked.
- Techno-inistutional complexes (TICs) emerge through synergistic co-evolution initiated by technological inreasing returns and perpetuated by the emergence of dominant technological, organizational and institutional design.

The techno-institutional complex



The techno-institutional complex - energy



Lock-in of public institutions

- The involvement of govt is important for two principal reasons.

  1) ability of institutional policy to override market forces. In the evolution of a technological system, govt intervention can remove market uncertainty about the direction of technological development through policy (RES).

  2) once the governmental institutions (formal, such as legal structures, or informal, such as culture, norms and values) are established they tend to persit in their initial form for extended period (agriculture subsidies, redundant offices).

2) Path dependency

- History (culture) shapes choices – path dependence (where we are now is the result of our decisions in the past).
- Superior technological variant doesn´t allways win out in dominant design frameworks. Inferior designs can become locked-in through a path-dependence process.

+ Some form of systematic barriers to the adoption of new energy systems (technologies).

= history matters.

Cost of durable capital

Hazelwood
power Station

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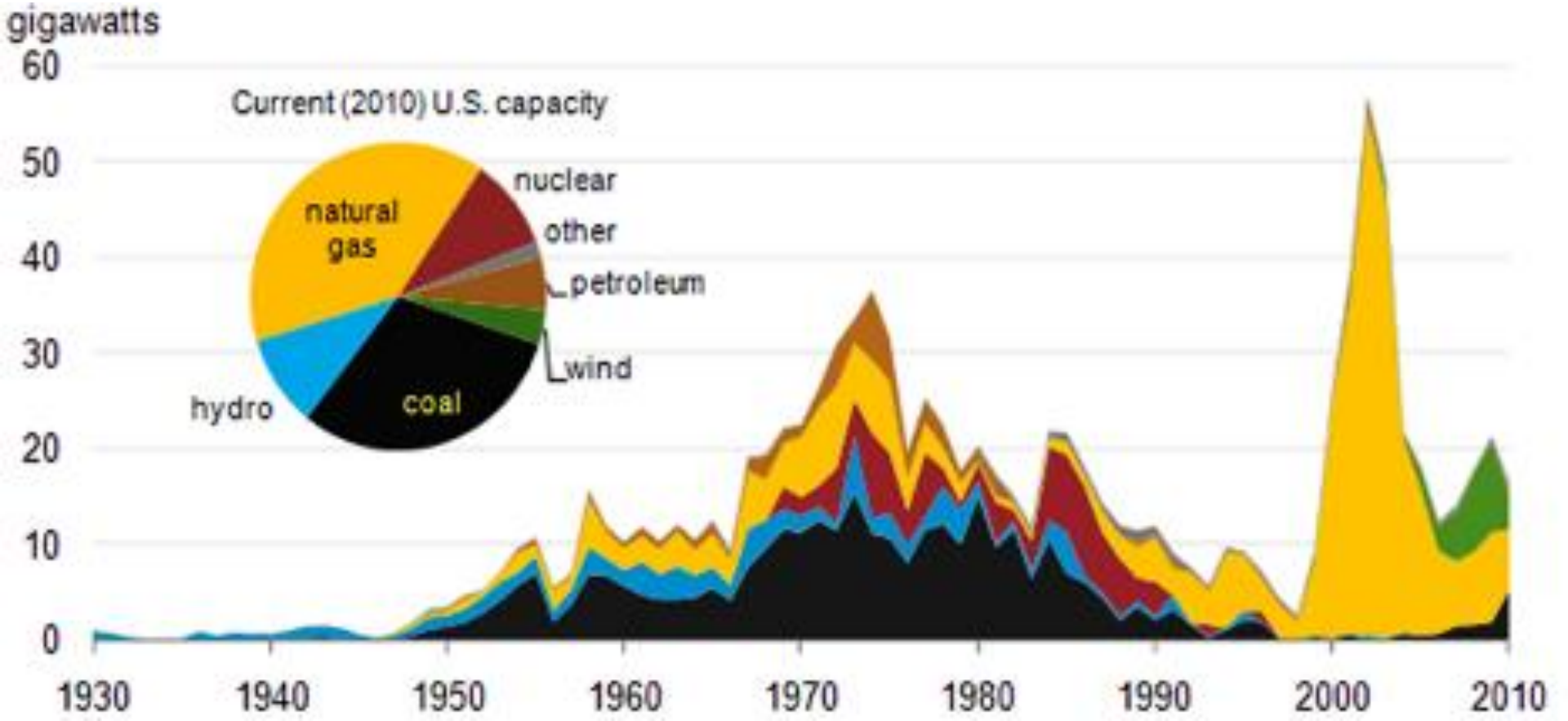
Cost of durable capital



3) Cultural and normative reasons: Polish coal

- Energy security = energy independence
- Domestic deposits of coal
- Security prevails environmental and economics reasons

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4) Political inertia

- Changes could be very disruptive – risk of unexpected results.
- Big changes in policy regimes rare (CAP of EU)
- Ideology matters

Changes in energy systems

1) Could be (and has been) done
2) Sometimes it takes research and development (sail to steam, coal to diesel locomotives)
3) Sometimes it takes changes in policy – nuclear energy
4) New systems face chicken-egg problem

Sources

- Gawande, A.: Getting there from here, 2009.
- Unruh, G.C.: Understanding Carbon Lock-in, 2000.
- Schmalensee, R.: Energy Decisions, Markets, and Policies, 2012.

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