The drivers of global fossil fuel consumption since 1950

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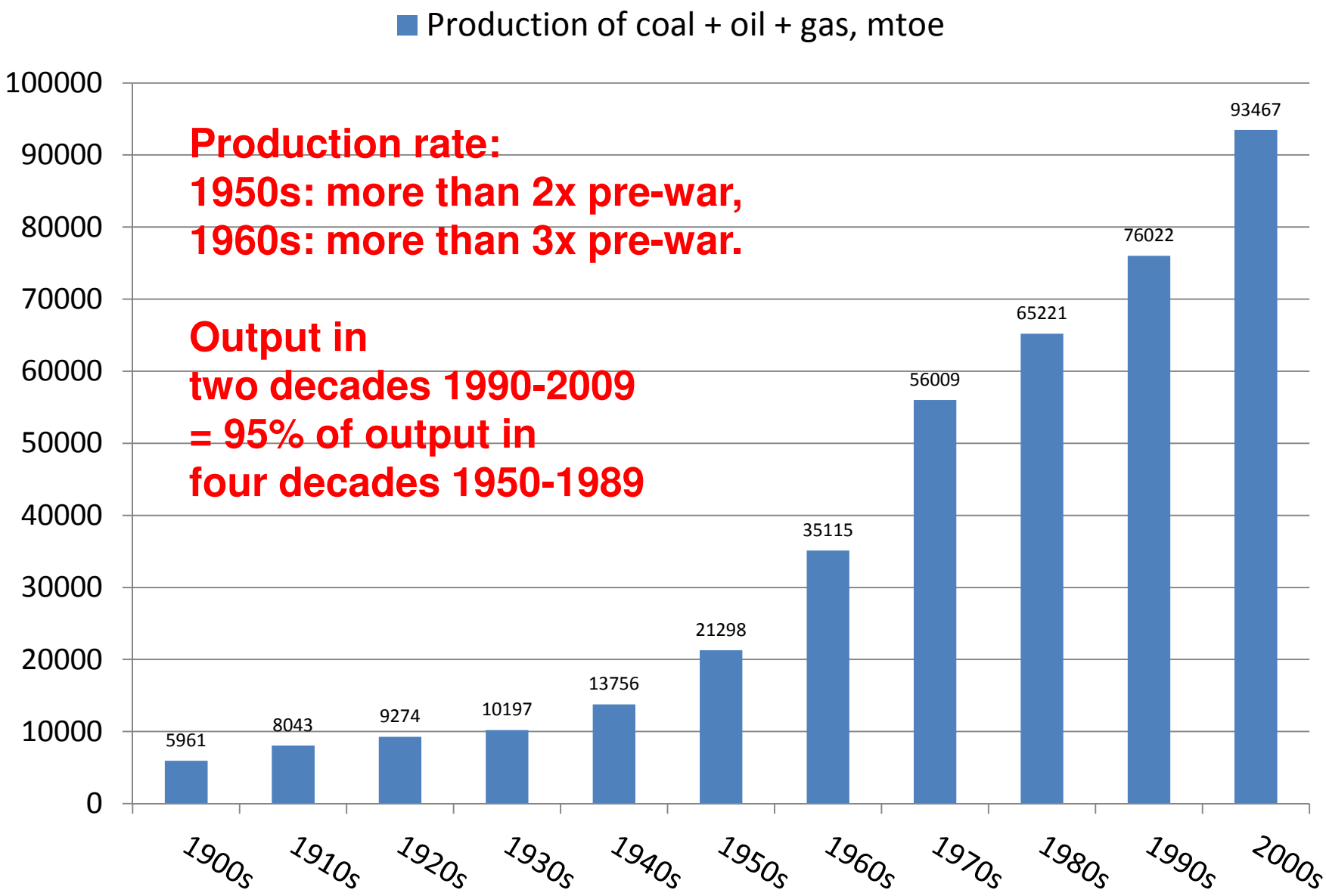
The historical background

- **The industrial revolution. From human and animal labour power to water and wood, and then coal**
- **New technologies that laid the basis for energy-intensive economies of the 20th c:**
  - **Electricity and electricity networks**
  - **Internal combustion engine and gas turbine**
  - **The Haber-Bosch process (to make fertiliser)**
- **The ten-fold + rise in the fossil fuel consumption rate in the 20th c. was driven by expansion and development of these, more than by new tech**

Global fossil fuel production 1900-2009



Source: Etemad and Luciani, *Production Mondiale de l'Energie, 1800-1985* (to 1980) and US EIA Historical Statistics (from 1981), via tsp-data-portal.org

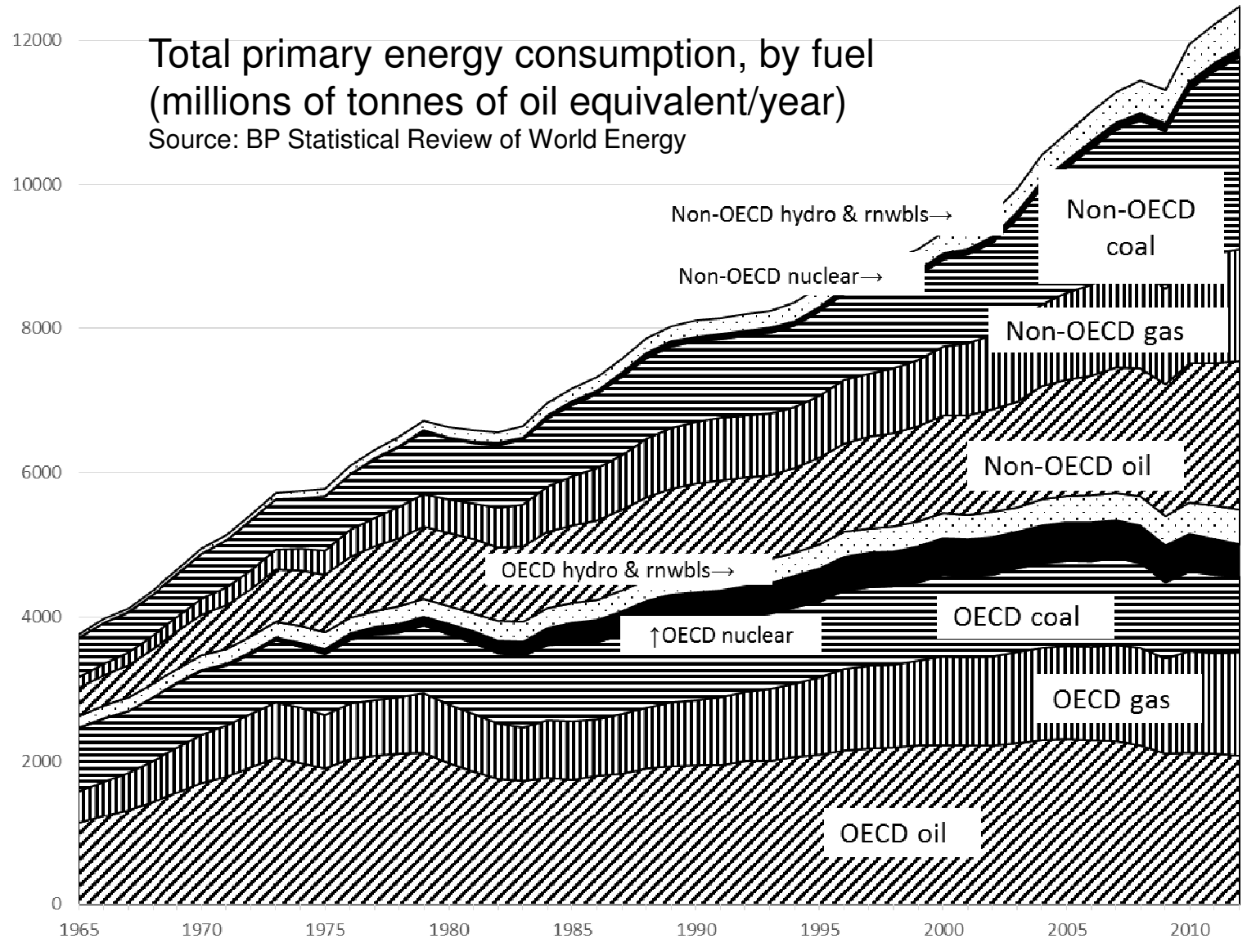
Global warming makes the past look different

To keep warming to 2º, the world economy can from 2010 use fossil fuels (depending which budget you use), roughly …

- **at the 1901-1950 level for 135-635 years;**
- **at the 1951-2000 level for 30-143 years; or**
- **at the 2001-2010 level for 13-79 years**

Million metric tonnes of carbon emitted	
1751-1850	1308
1851-1900	10999
1901-1950	50017
1951-2000	221536
1991-2000	64418
2001-2010	80865
Total cumulative 1751-2010	364725
Total carbon budget (Hansen et al)	500000
Total carbon budget (IPCC)	1000000
Remaining budget (Hansen)	135275
Remaining budget (IPCC)	635725

Ways of counting consumption are contested



IPAT and its variants

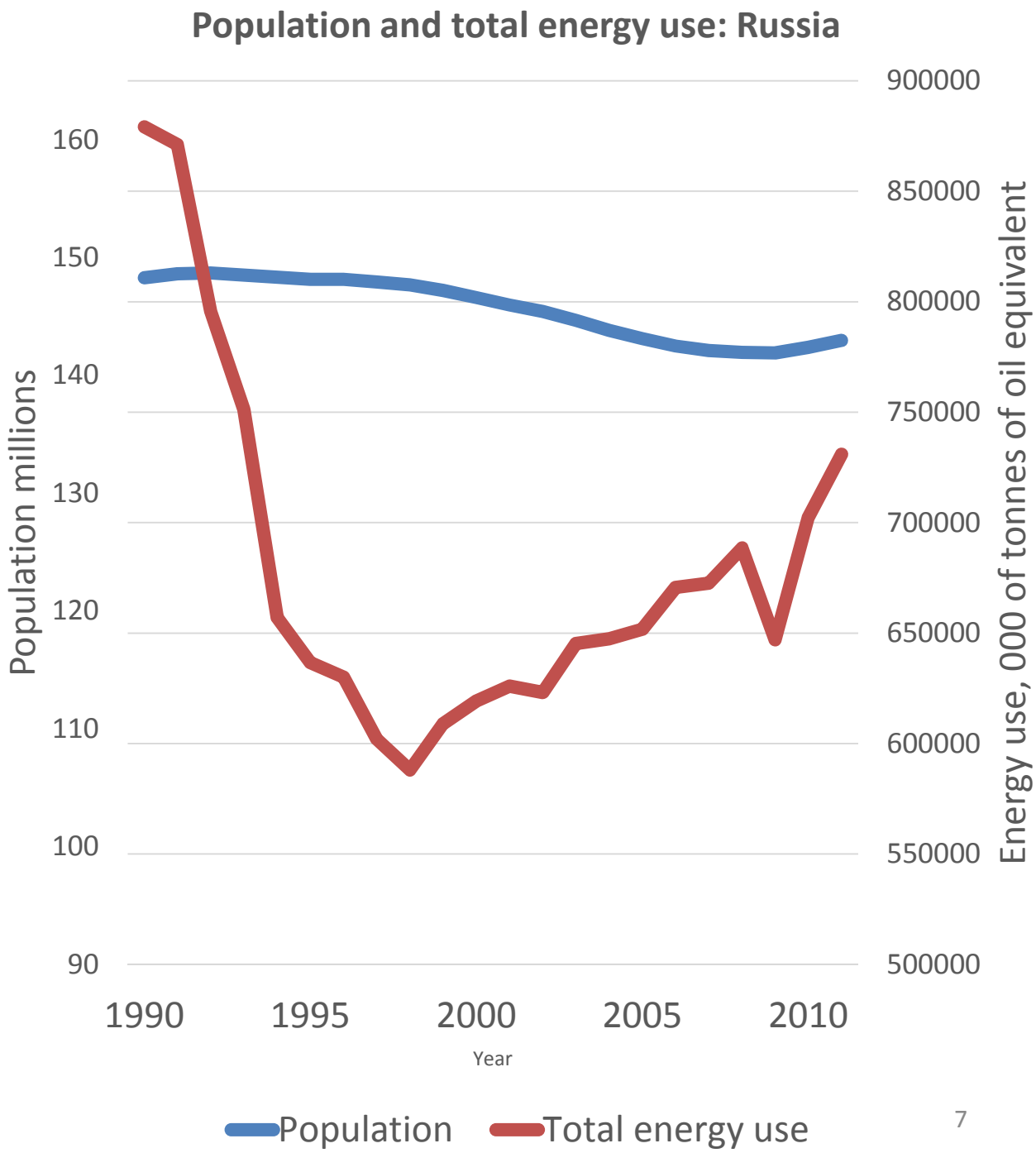
Impact = population x affluence x technology
(proposed by Paul Ehrlich and John Holdren in polemic with Barry Commoner about pressure on resources, 1972)

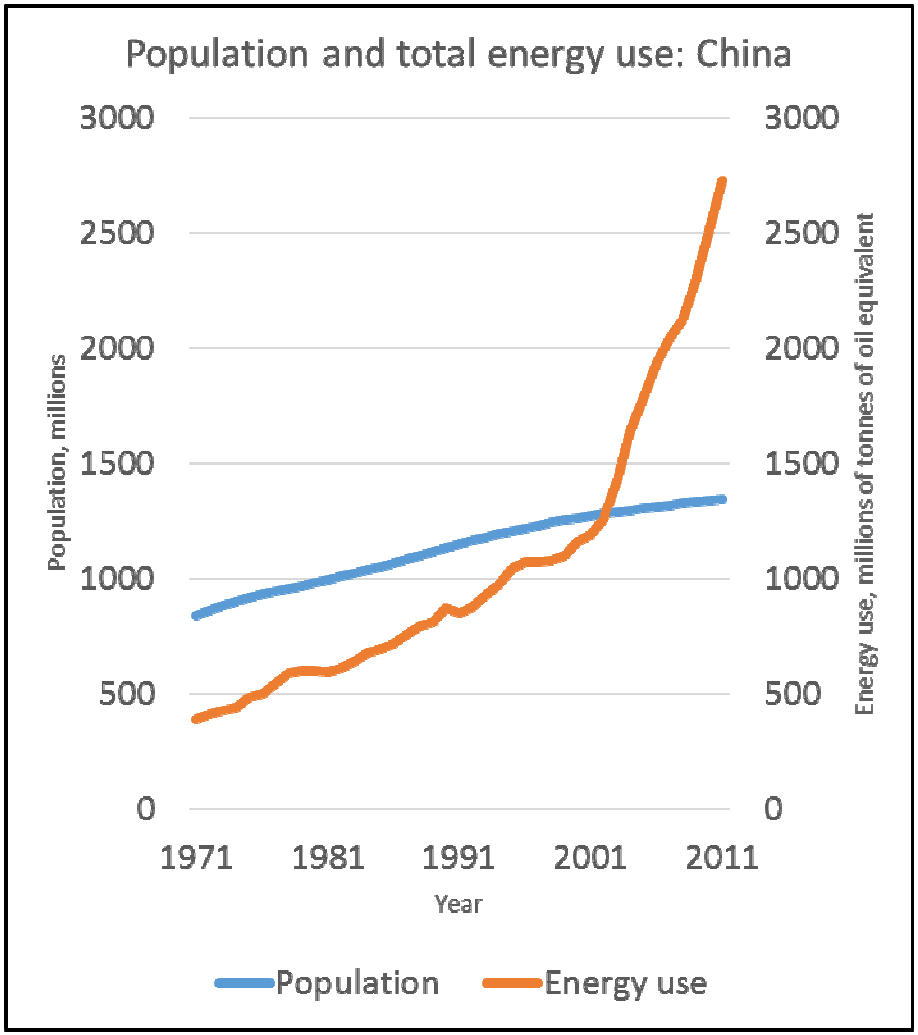
The Kaya identity: emissions = population x (GDP/population) x (energy/GDP) x (emissions/energy)
(proposed by Yoichi Kaya and his colleagues to look at the drivers of greenhouse gas emissions)

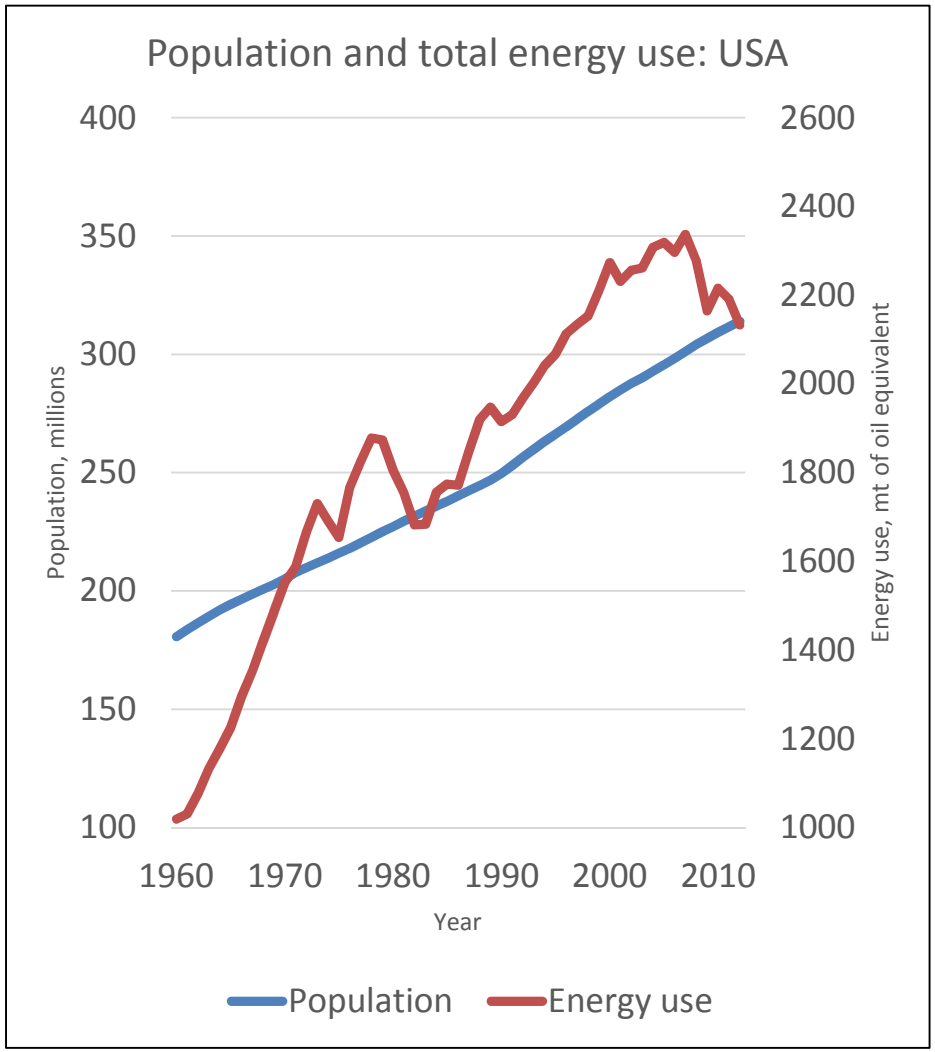
T. Dietz and E. Rosa pointed in the 1990s to IPAT's "serious limitations". Rosa pioneered STIRPAT, a development of the equation used for empirical research (structural human ecology). But in 2012 Dietz and Rosa considered that the literature remained "blinkered across disciplines".

Can rising population be assumed to be the main driver of rising energy use?

People consume energy mostly indirectly (via economic, social and technological relationships).

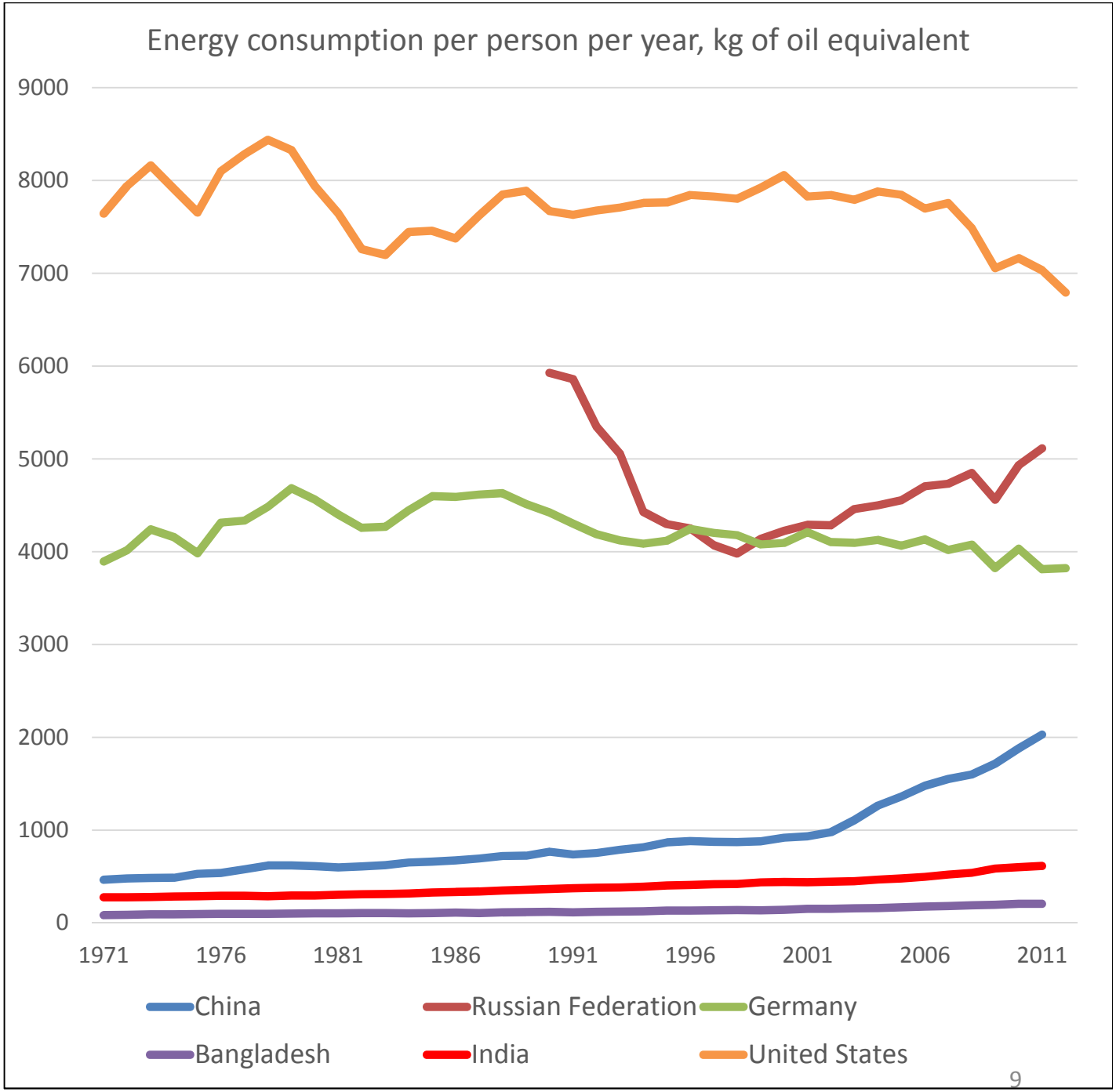



Population and total energy use: China
3000
2500
2000
1500
1000
500
0
Population, millions
Energy use, millions of tonnes of oil equivalent
1971
1981
1991
2001
2011
Year
Population
Energy use


Population and total energy use: USA
400
350
300
250
200
150
100
2600
2400
2200
2000
1800
1600
1400
1200
1000
Population, millions
Energy use, mt of oil equivalent
1960
1970
1980
1990
2000
2010
Year
Population
Energy use

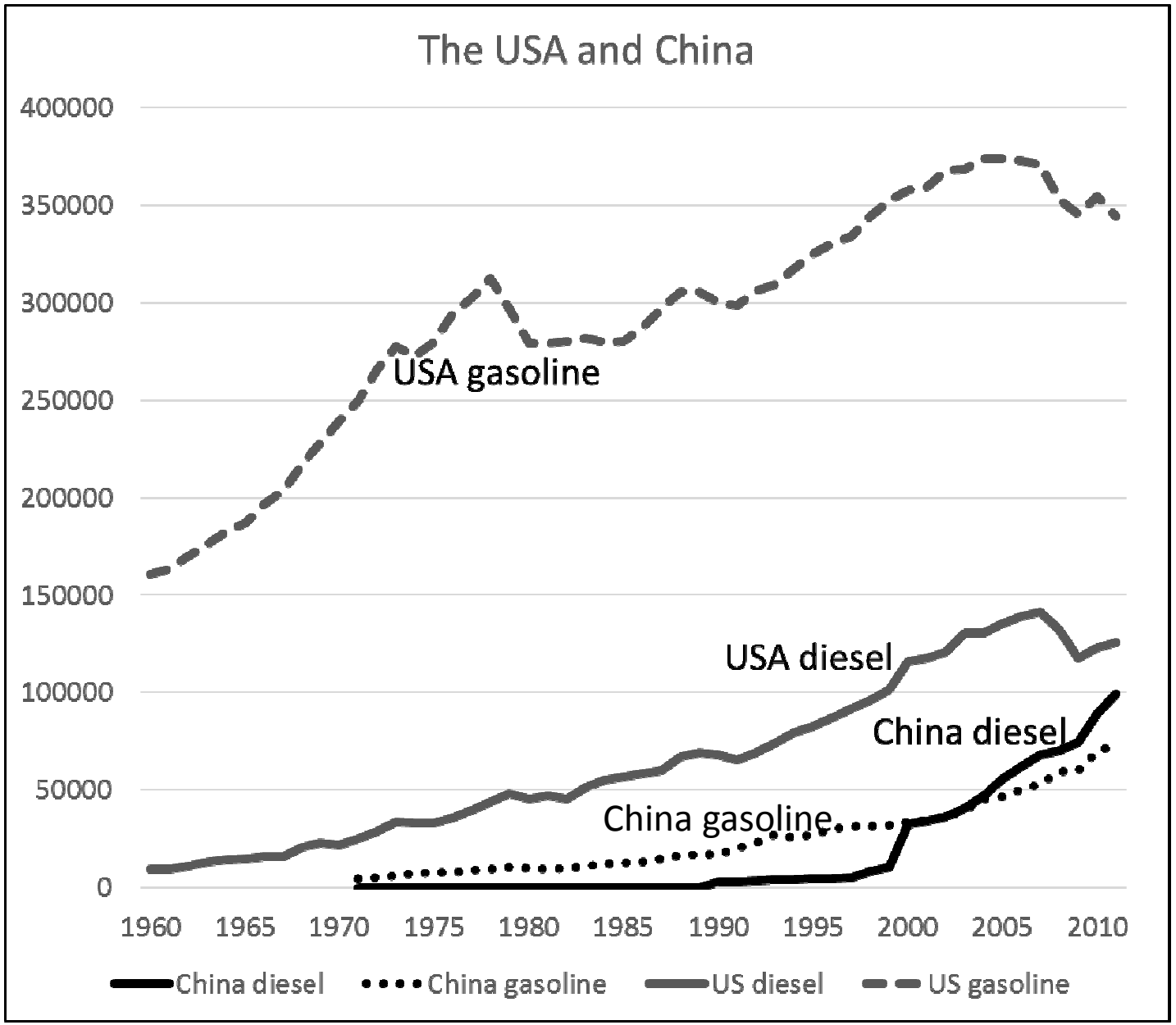
National consumption-per-person statistics are a reminder of the yawning gap between the haves and have-nots. But they can not reflect ...

- **Inequalities within nations;**
- **Energy systems and consumers' relationship to them; or**
- **The role of industry.**



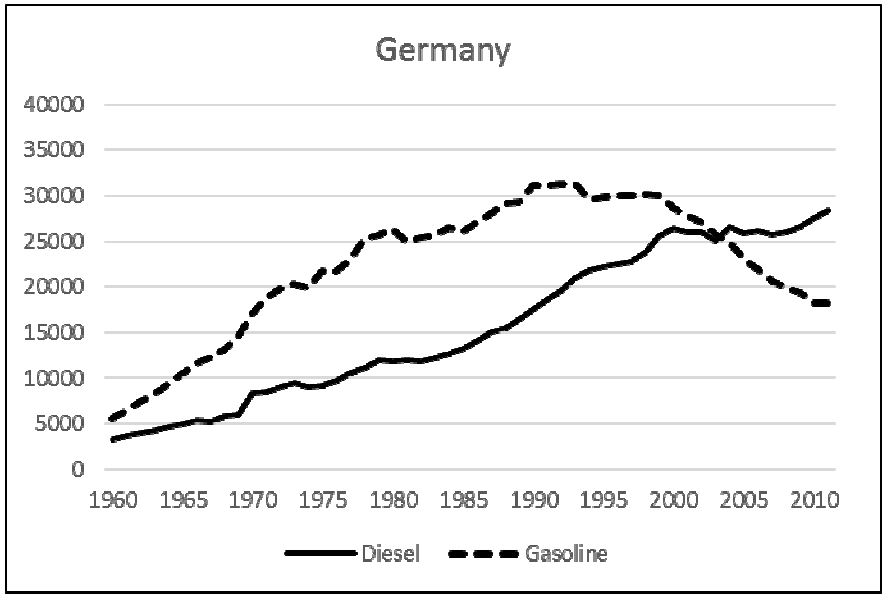
Source: World Bank World Development Indicators

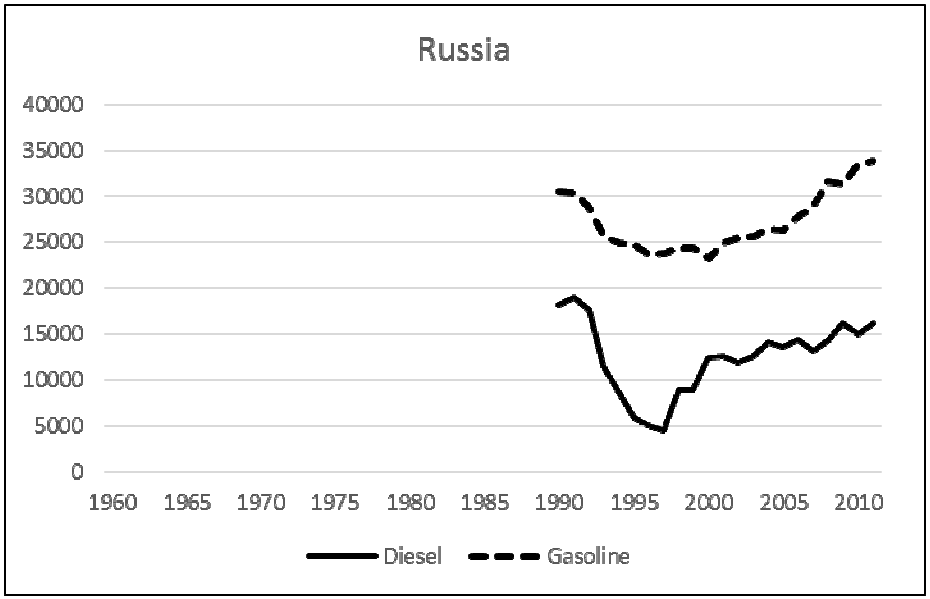
Diesel and gasoline consumption, 000 tonnes of oil equivalent, 1960-2011

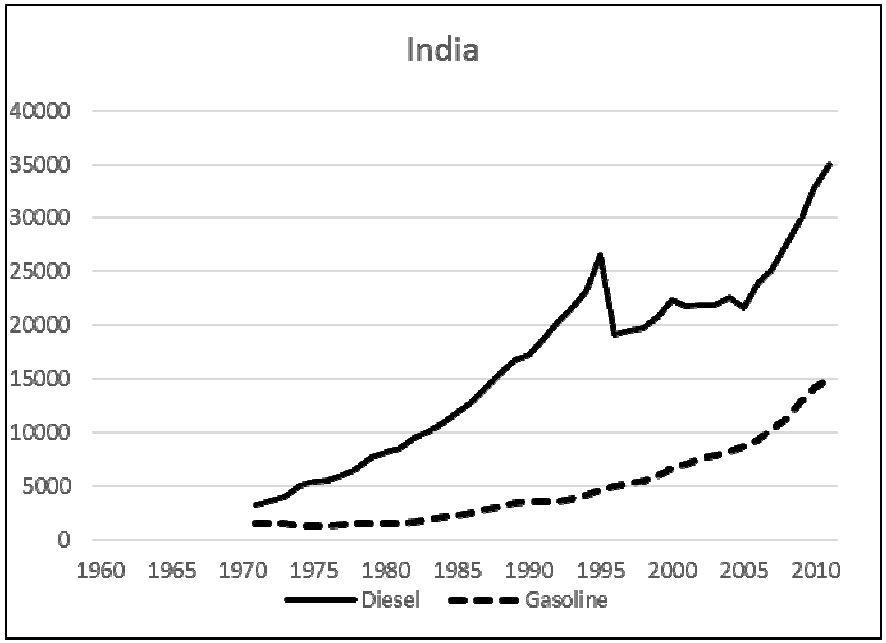


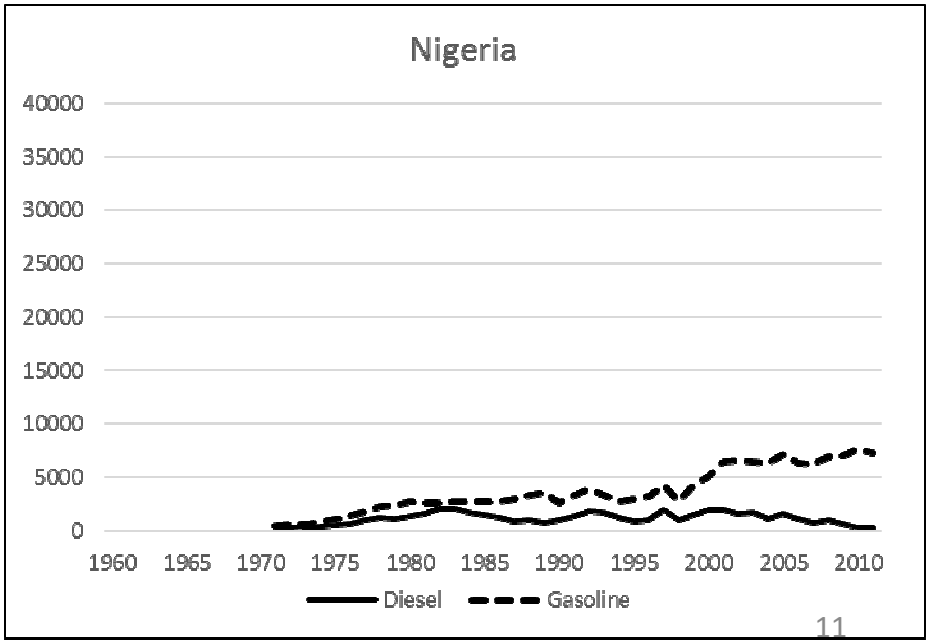
Source: World Bank/ International Road Federation World Road Statistics

Diesel and gasoline consumption, 000 tonnes of oil equivalent, 1960-2011









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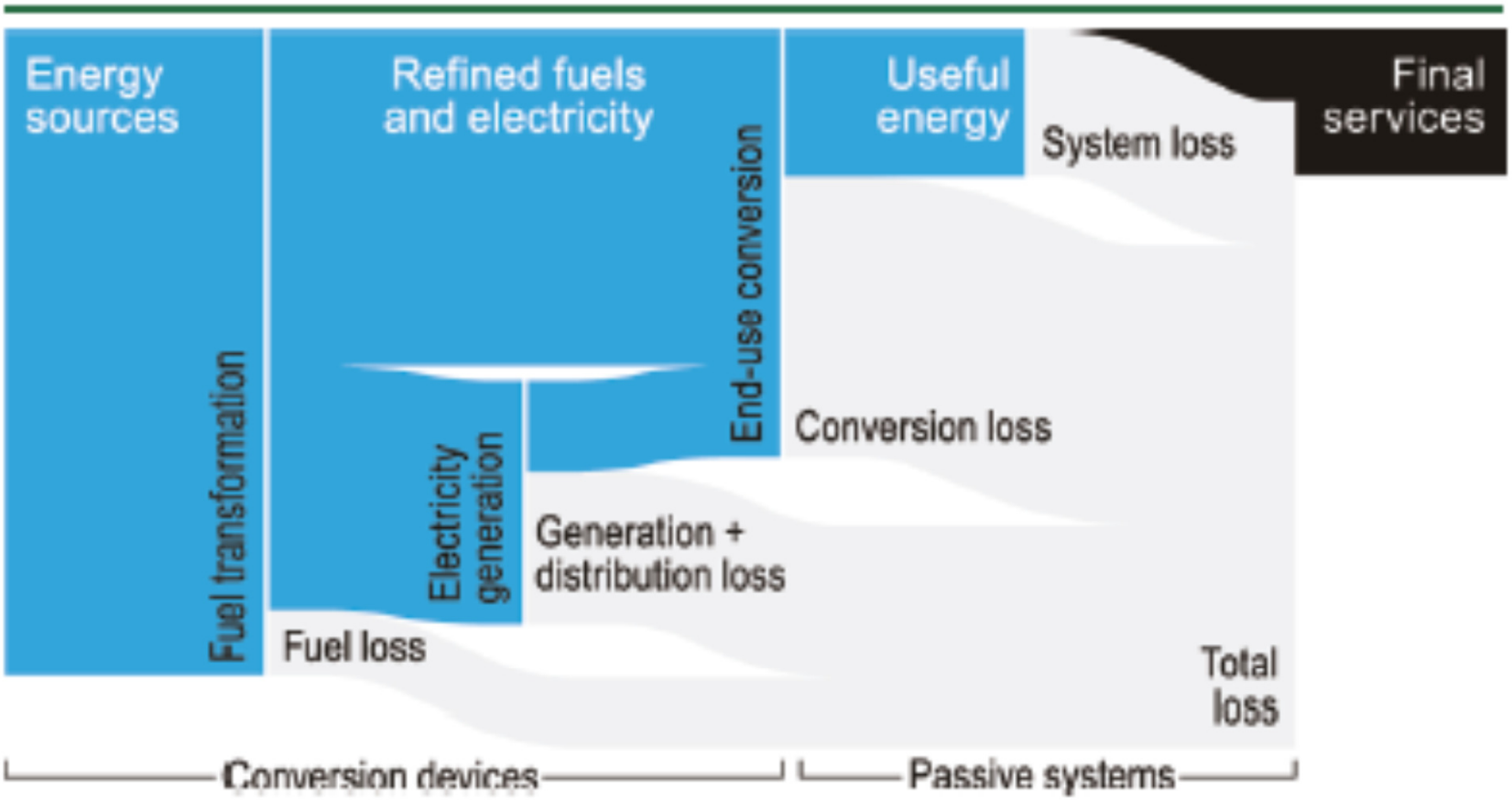

Figure 1. Schematic Sankey diagram for provision of energy and material services showing losses, reproduced with permission from ref 22.

From Cullen et al., "Reducing Energy Demand: what are the practical limits", Environmental Science and Technology 45 (2011), p. 1713

China's energy consumption, 2011		per cent	millions of tonnes of oil equivalent
Total primary energy supply		**100**	**2727.7**
Energy lost in producing electricity		22.6	616.9
Energy lost in producing heat		0.8	20.6
Gas works, artificial fuel plants and liquefaction plants		1.4	38.7
Oil refineries		0.4	10.9
Other energy industry own use and losses		6.9	188.0
Transfers and statistical differences		4.3	117.8
Total final consumption (37.5% coal, 27.1% oil and gas, 19.1% electricity, 3.7% heat and 1.2% other fuels)		**63.6**	**1734.8**
Industry	Iron & steel (including coal in blast furnaces)	11.8	321.9
	Chemical & petrochemical (including fertilisers)	6.2	170.4
	Non-ferrous metals	1.7	46.7
	Cement and other non-metallic minerals	6.1	165.2
	Machinery and transport equipment	2.4	66.3
	Food & tobacco	1.0	28.2
	Textile and leather	1.1	29.2
	Other industry and construction	6.1	165.9
Transport	Domestic aviation	0.4	11.1
	Road	6.2	169.4
	Rail	0.4	12.2
	Domestic navigation and other transport	0.9	25.6
Residential		13.5	367.5
Commercial and public services		2.4	64.2
Agriculture and forestry		1.2	33.5
Other		2.1	57.4

Source: adapted from IEA Energy Balances 2011

Ways of counting consumption: research issues

- **Do IPAT and its variants set a flawed context, by making individual consumption an absolute and downplaying the role of social, economic and technological systems?**

- **Are there data that better reflect the role of those systems?**

Change through time: rich countries' economic history

- **Cheap energy has stimulated energy-intensive industry and agriculture, and disfavoured other technology**
- **1950s and 60s. Post-war boom. Growth of industrial and agricultural production, and of urban infrastructure, in developed countries. Parts of Europe reached higher, USA-style living standards. Oil and gas grew faster than coal.**
- **1970s. Recession, and high oil prices, dampened energy demand.**
- **1980s. Conservation policies eclipsed by renewed demand growth.**
- **1990s and 2000s. A new leap in fossil fuel use is driven by economic expansion; rich-country consumption; and coal-fuelled industrialisation of China and other Asian countries.**

Change through time: a history of inequality

- Pre-1980s, rich countries mostly had commercial, fossil-fuel-based energy systems and electricity grids, and poor countries did not.
- Electrical and energy systems were exported to developing countries to serve the international economy, not people's needs.
- Big systems (technological, economic and corporate) were copied wholesale
- These systems excluded the poorest, who continue to rely on traditional biofuels, or go without. (2010: 1.4 bn people had no electricity; 2.4 bn people were cooking with traditional biomass.)
- Fossil fuel based systems in China and elsewhere serve urban industrial complexes
- The gap between consumption levels of richest and poorest is hard to measure, but seems to have widened

Change through time: people and technological systems

- Cultural historians have mapped changing consumption habits, of energy and of stuff produced by energy.
- Some historians' emphasis on consumers' agency neglects the restrictions imposed by systems (e.g. millions of Americans who can not reach the local school, shop or workplace except by car).
- Most energy is consumed by technological systems operating within particular economic and social relationships.
- Why do big systems persist, and constrain alternative technologies, both large (US mass transit, combined heat and power) and small (solar panels, heat pumps)?
- What role is played by corporations that control technology and investment?
- What role is played by the commodification of energy?

Change through time: how and why energy policy failed

- After the 1970s “oil shocks”, environmentalism and demand management began to be taken seriously in US politics. From the mid-1980s it was rejected by government
- Government and corporations eschewed new technologies and favoured investment in fossil fuels and nuclear
- Scientific consensus on climate change (late 1980s) and the UN framework agreement (1992) was followed by a gigantic acceleration of global fossil fuel consumption
- In the 2000s (particularly as oil prices rose), state subsidies to fossil fuel consumers and producers expanded
- The Copenhagen summit of 2009 in practice marked the failure of efforts to achieve international agreement on emissions reduction

A historian's research questions

- **How can the history of the global economy, technological systems, social consumption trends and politics be integrated?**
- **How to assess the centrality of fossil fuel consumption to capitalist economy without normalising it (e.g. with concepts such as "fossil fuel civilisation").**
- **How can the repeated and persistent rejection of non-fossil-fuel technologies, particularly after 1990, be explained?**
- **What interpretive framework can explain the catastrophic failure of international climate change policy, culminating at Copenhagen? (Or: why did they fail with greenhouse gases where they succeeded with ozone?)**
- **Should we try to anticipate the questions that will be asked by future historians, who might perceive our time as one of collective madness?**