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Sociometabolic transitions in human history and present, and their impact upon biodiversity

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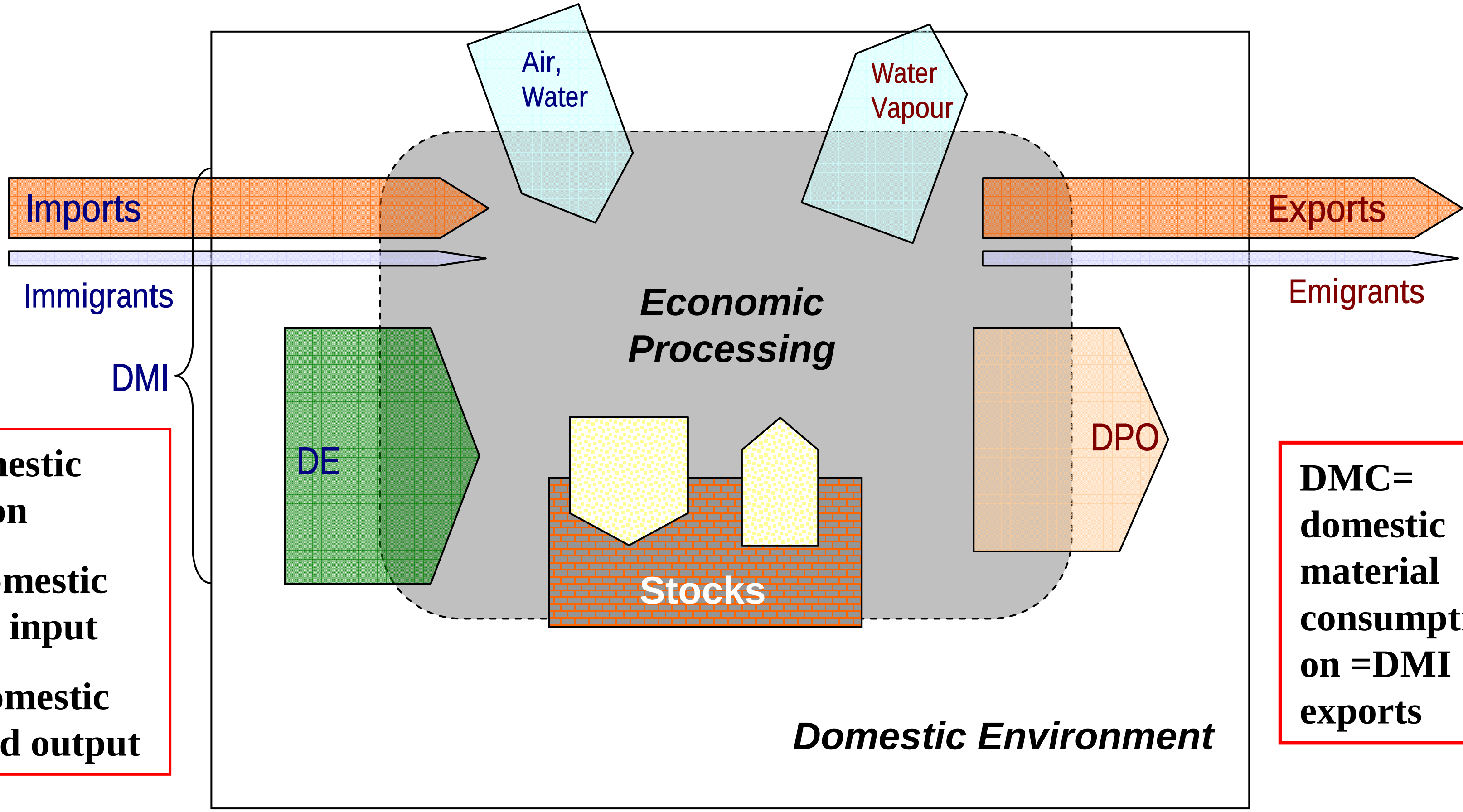
Outline

1. Conceptual clarifications: social metabolism and metabolic profiles, sociometabolic regimes, transitions
2. key features of the historical transition from the agrarian to the industrial regime
3. patterns of ongoing transformations in the South, in relation to the historical Northern transition, and in the context of global interdepency
4. How does all this relate to biodiversity, and to understanding trajectories of change?

Social metabolism – metabolic profile

- Organismic analogy: any social system, like an organism, requires a steady flow of energy and matter to reproduce itself
- How much, and what kind of energy and matter it requires, is deeply built into the structures and functioning of the social system, and beyond certain points hard to change (metabolic profile).
- The toolbox and indicators of material & energy flow analysis (MEFA) match, in units of tonnes and joules, the toolbox of macroeconomic accounting, in monetary units.
- The social system‘s material and energy requirements, both on the input side (resource extraction) and on the output side (wastes and emissions) constitute pressures upon the environment, and induce changes.
- Social metabolism: hinge concept/methodology between socioeconomic systems and ecological systems

Model of material social metabolism (according to MEFA)



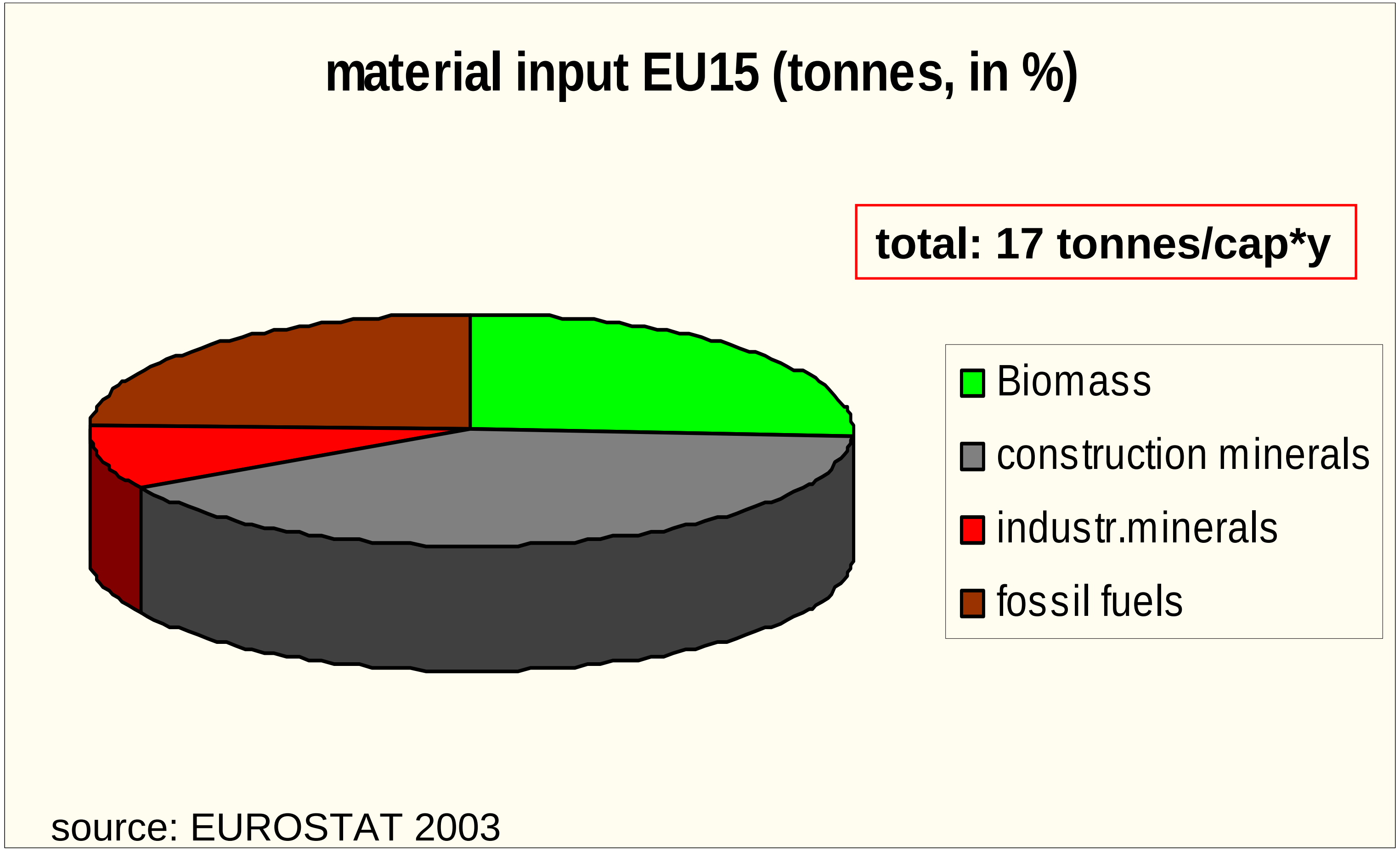
DE=domestic extraction

DMI=domestic material input

DPO=domestic processed output

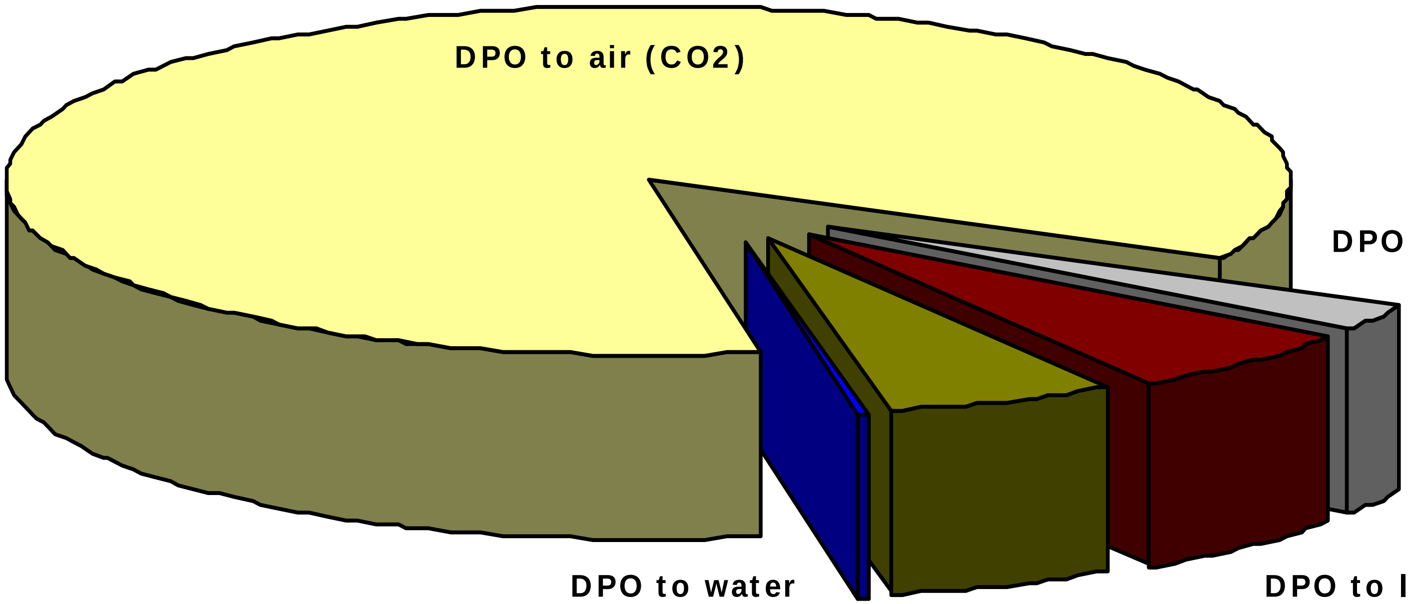
DMC= domestic material consumption =DMI - exports

composition of materials input (DMC)



Composition of DPO: Wastes and emissions (outflows)

DPO total: 16 tons per capita



unweighted means of DPO per capita for
A, G, J, NL, US; metric tons

Source: WRI et al., 2000; own calculations

Sociometabolic regimes

The theory of sociometabolic regimes (Sieferle) claims that, in world history, certain modes of human production (Ricardo, Marx) and subsistence (Adam Smith, Diamond) can be broadly distinguished that share, at whatever point in time and irrespective of biogeographical conditions, certain fundamental systemic characteristics, derived from the way they utilize and thereby modify nature.

Key constraint: energy system (sources of energy and main technologies of energy conversion).

Result: characteristic metabolic profile (range of materials and energy use per capita)

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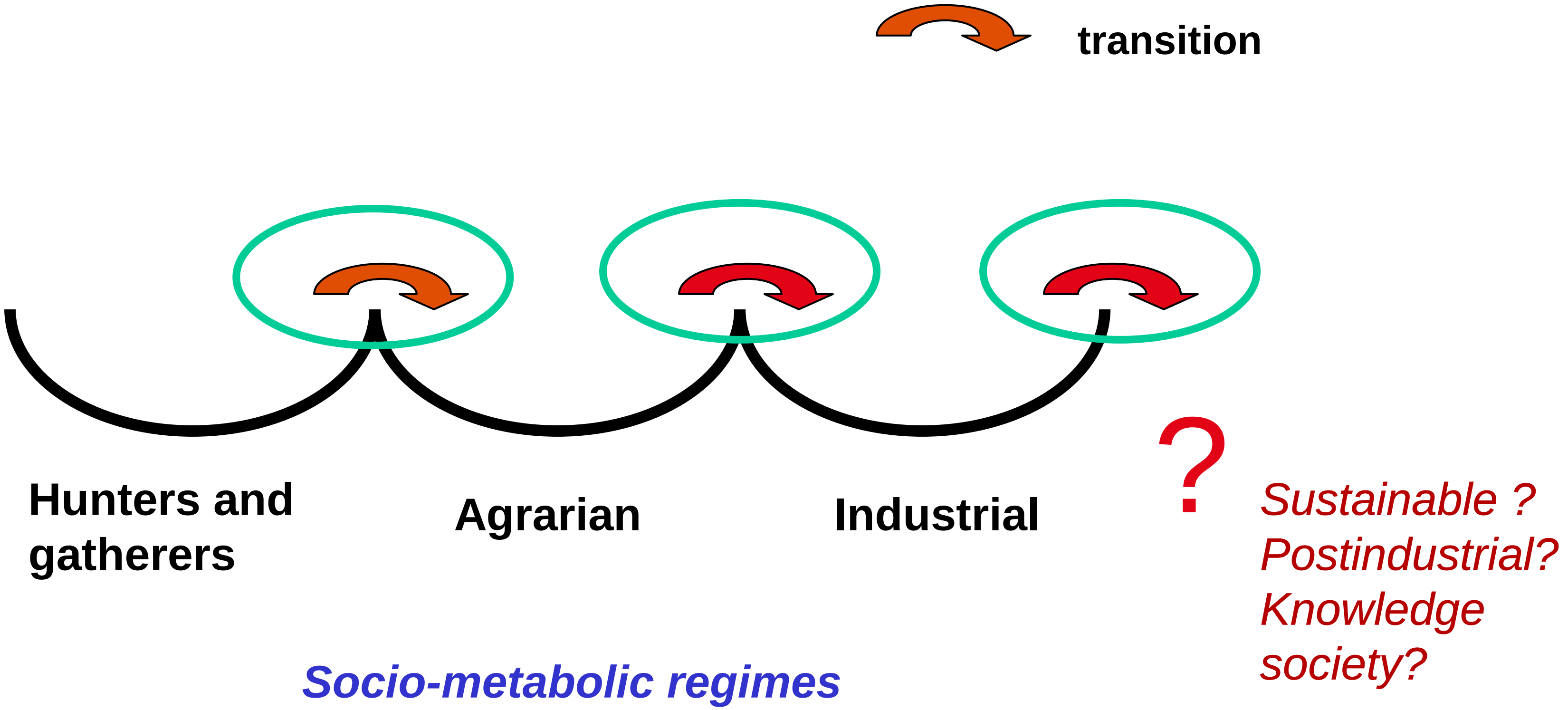
Sociometabolic regimes can be characterized by ...

1. a metabolic profile, that is a certain structure and level of energy and materials use (range per capita of human population)
2. secured by certain infrastructures and a range of technologies, as well as
3. certain economic and governance structures.
4. A certain pattern of demographic reproduction, human life time and labor structure, and
5. a certain pattern of environmental impact: land-use, resource exploitation, pollution and impact on the biological evolution
6. Key regulatory positive and negative feedbacks between the socio-economic system and its natural environment that mould and constrain the reproduction of the socioecological regime.

Transitions between sociometabolic regimes – research strategy



Source: Sieferle et al. 2006, modified

Transitions

Within regimes gradualism and path dependency prevail: the system moves along a path, „maturing“ into a certain direction, often towards a „high level equilibrium trap“ (Boserup 1965, Sieferle 2003), until:

- that path is either interrupted from outside (such as: Mongol invasion, major volcano eruption), or
- the system implodes / collapses, and possibly falls back to an earlier stage of that same path (Diamond 2005)
- or particular (contingent) conditions allow for a transition into another sociometabolic regime

Transitions between regimes can be turbulent and chaotic; they are usually irreversible; there is no predetermined outcome or directionality.

Part 2:

The transition from the agrarian to the industrial socioecological regime in history (1600-2000)

Historical sociometabolic regimes

Agrarian regime:

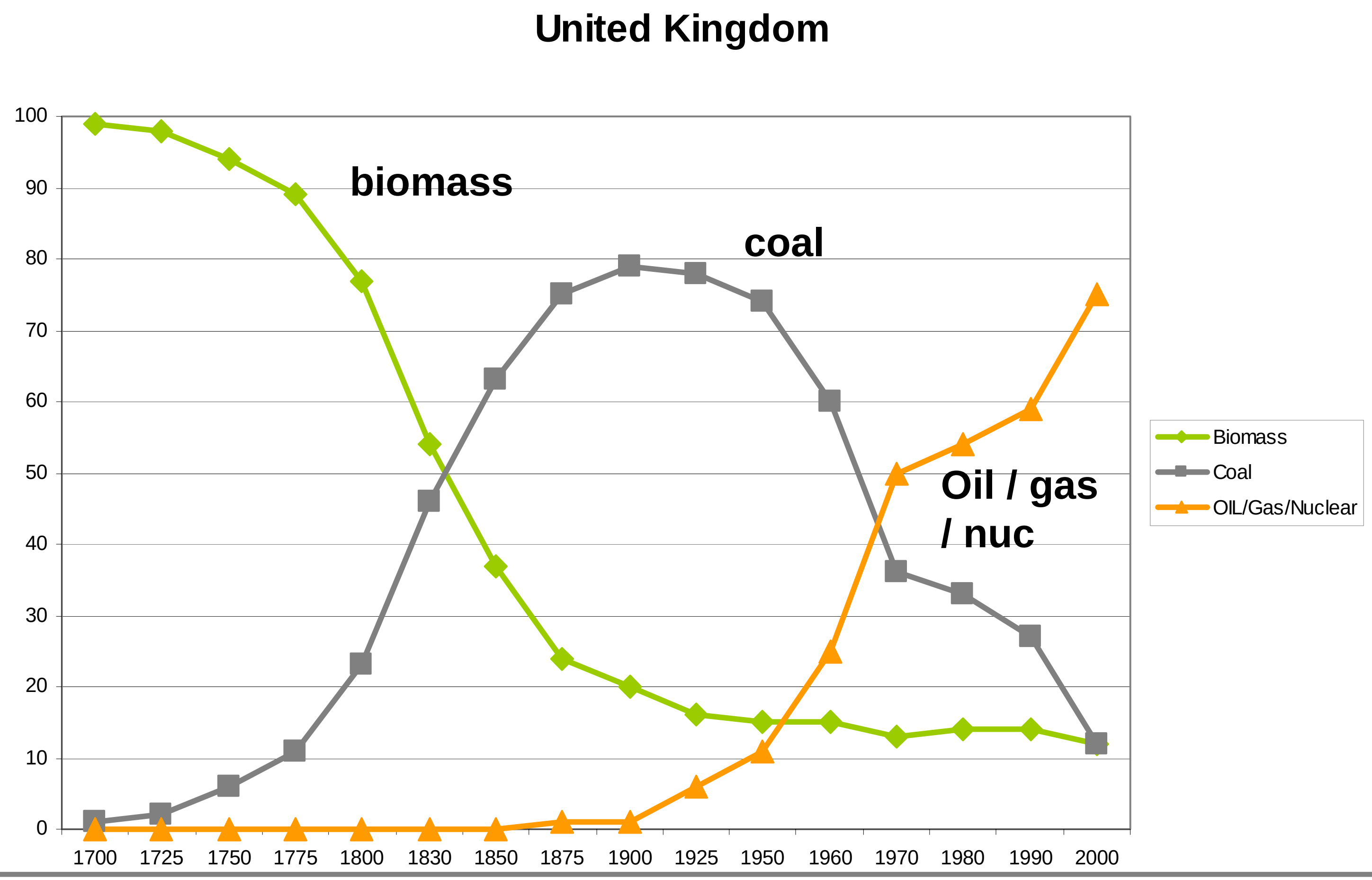
1. Solar energy, resource base flow of biomass.
2. infrastructures decentralized. key technology: use of land through agriculture;
3. subsistence economies & market; if more complex, strong hierarchical differentiation;
4. tendency of population growth and increasing workload;
5. potentially sustainable, but soil erosion, wildlife / habitat reduction;
6. distinct limits for physical growth (low energy density);

Industrial regime:

1. Fossil fuel based; exploitation of large stocks;
2. centralized infrastructures, industrial technologies;
3. capitalism and functional differentiation;
4. thrifty reproduction, prolonged socialization, somewhat lesser workload;
5. large-scale pollution (air, water and soil), alteration of atmospheric composition, depletion of mineral resources, biodiversity reduction;
6. abolishment of limits to physical growth; decoupling of land and energy and labour;

the energy transition 1700-2000: from biomass to fossil fuels

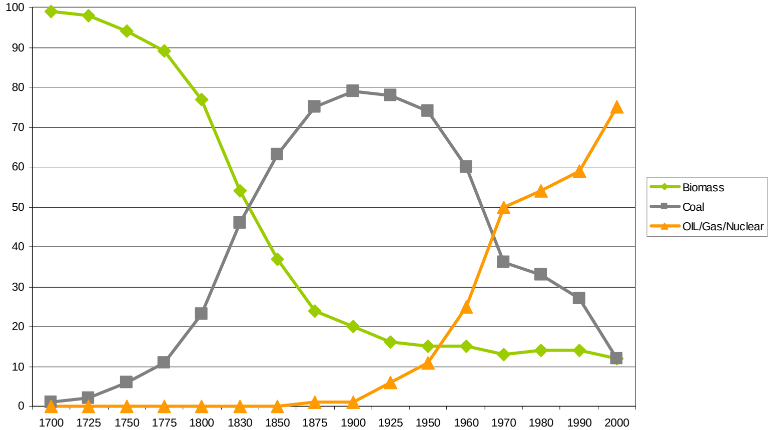
Share of energy sources in primary energy consumption (DEC)



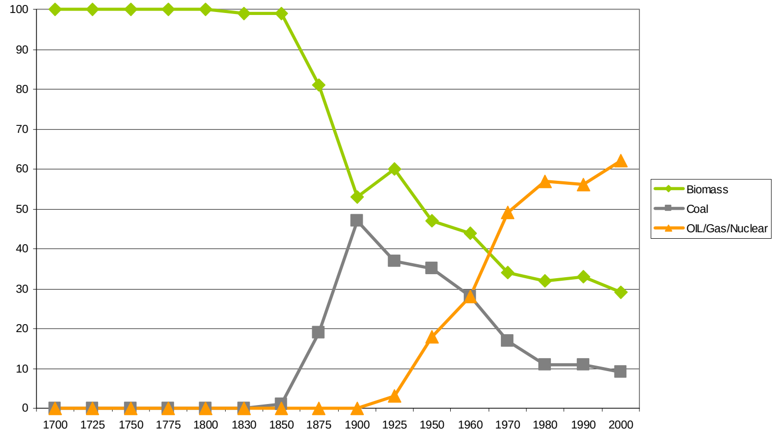
Source: Social Ecology Data Base

the energy transition 1700-2000 - latecomers

UK



Austria



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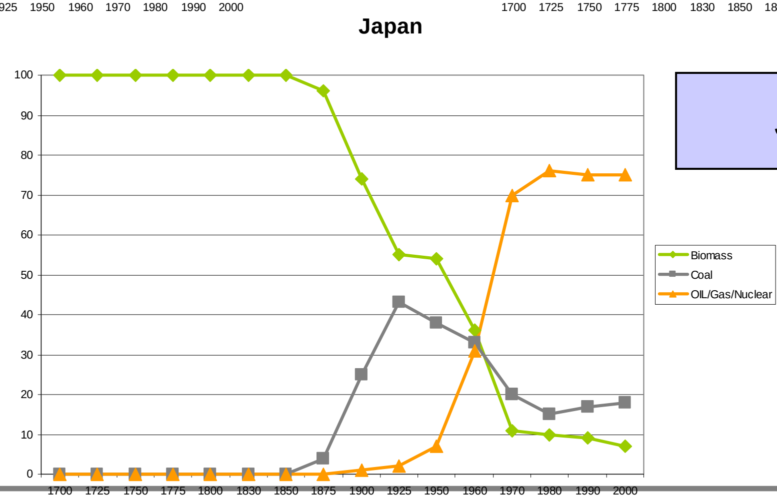
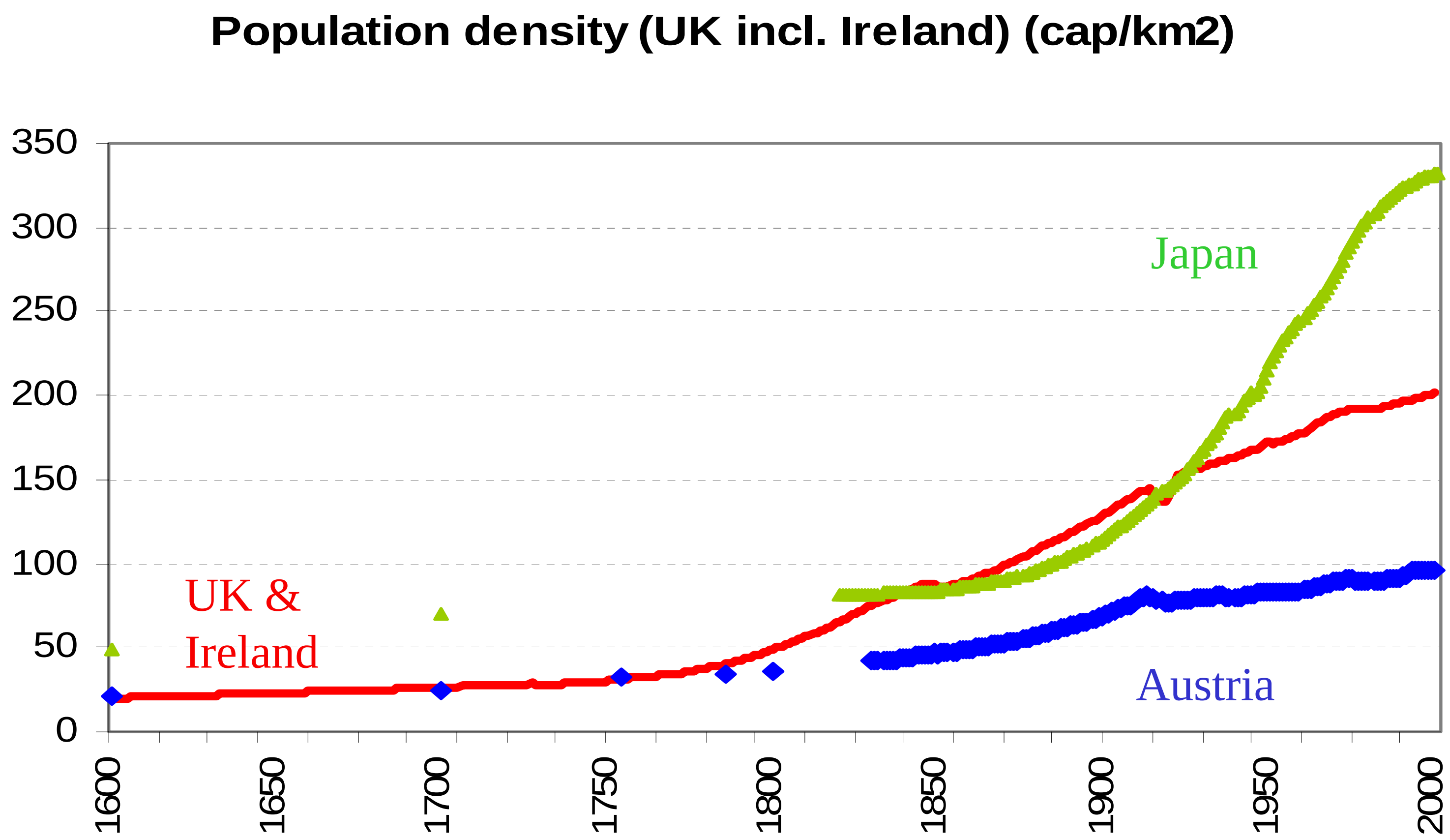


Japan

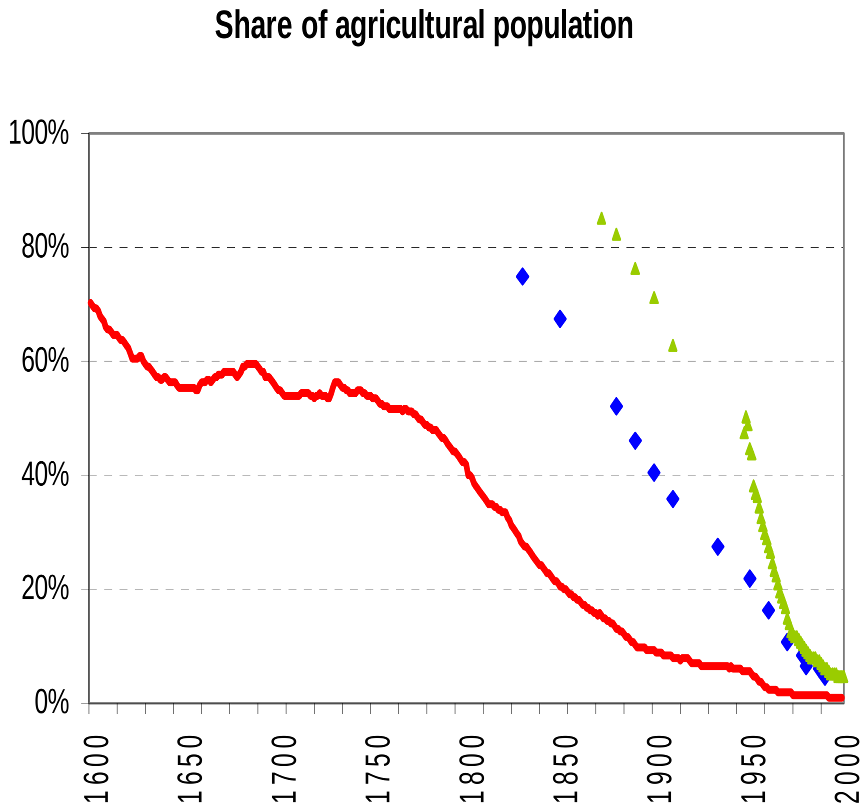
Source: Social Ecology Data Base

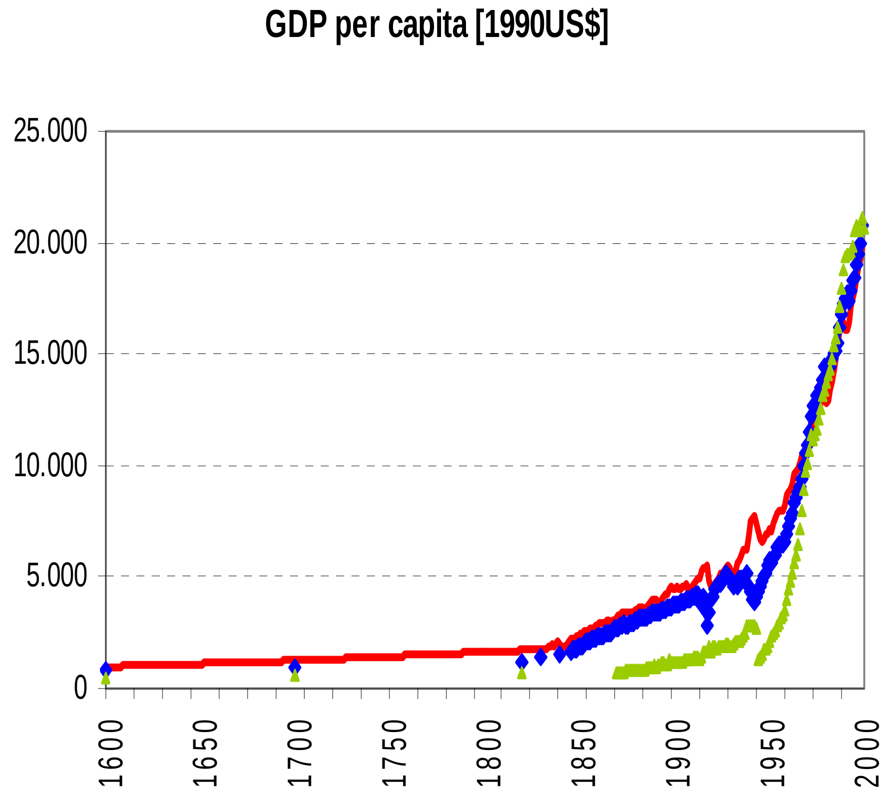
Increasing population (density) 1600-2000



Source: Maddison 2002, Social Ecology DB

Reduction of agricultural population, and gain in income 1600-2000





Source: Maddison 2002, Social Ecology DB

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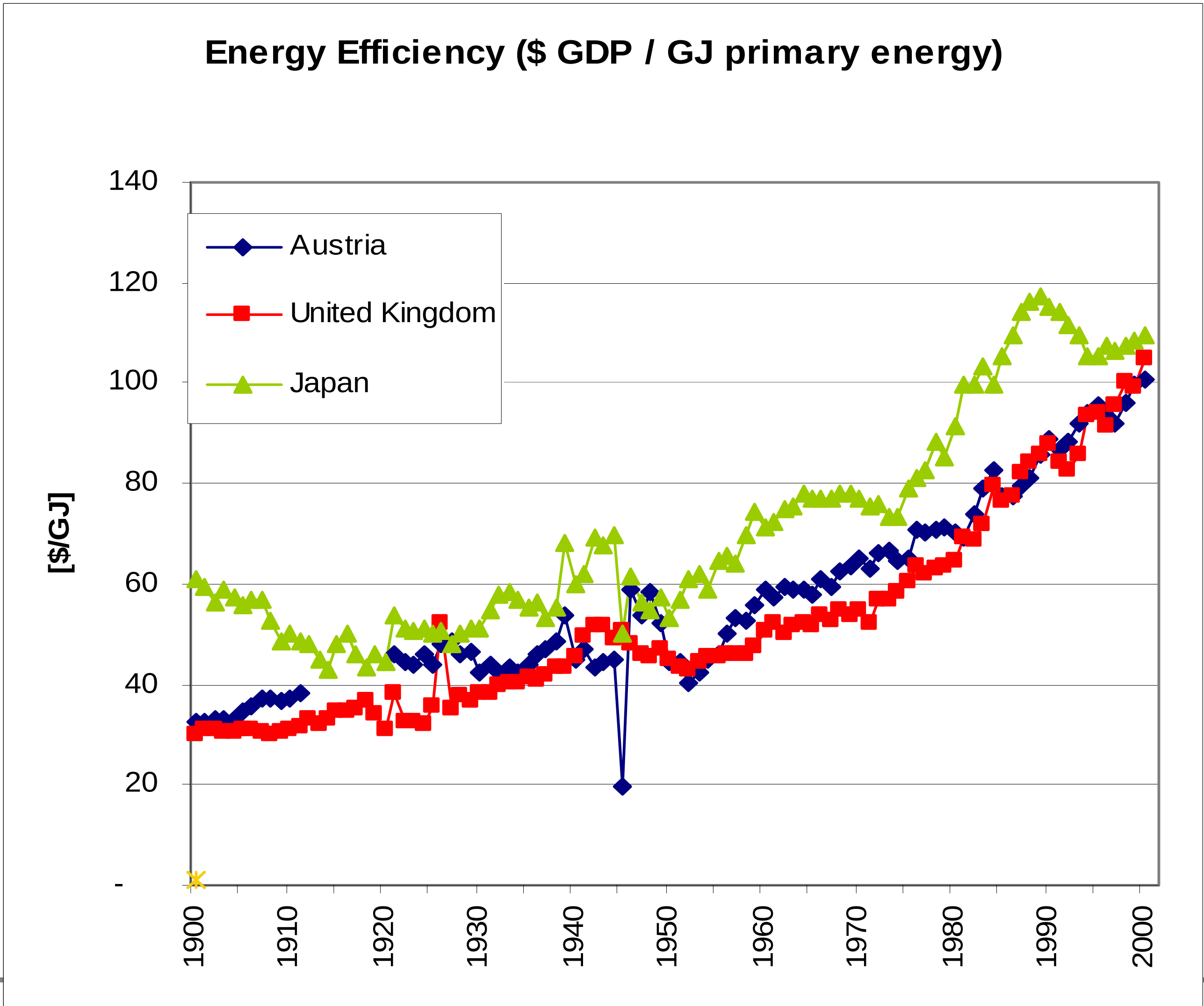
Longterm increase in economic energy effciency (1900-2005)



Efficiency increases: Average 11 % per decade, or roughly 1% annually.

Source: Social Ecology DB

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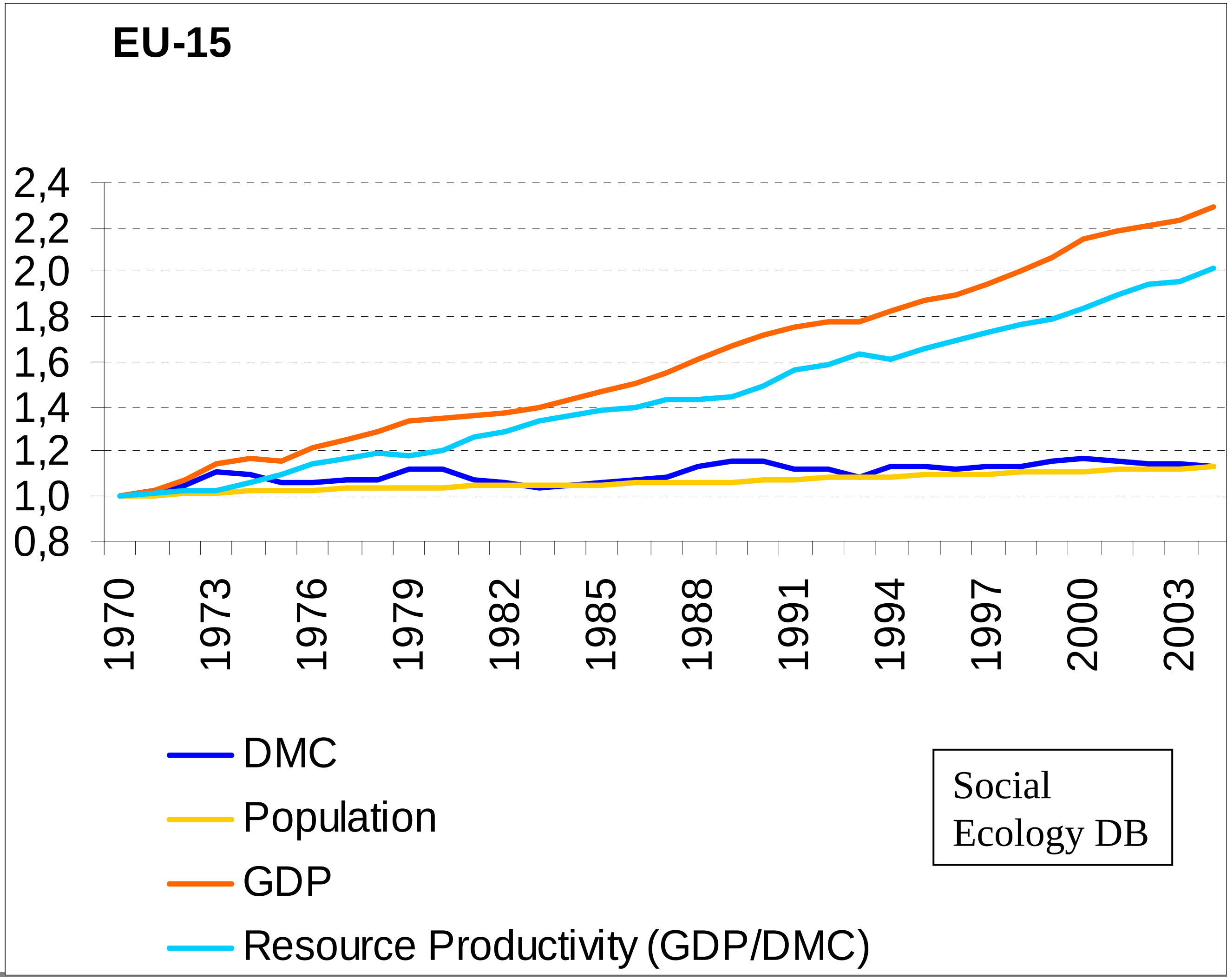
Increasing economic material efficiency (while metabolic profile fairly constant)



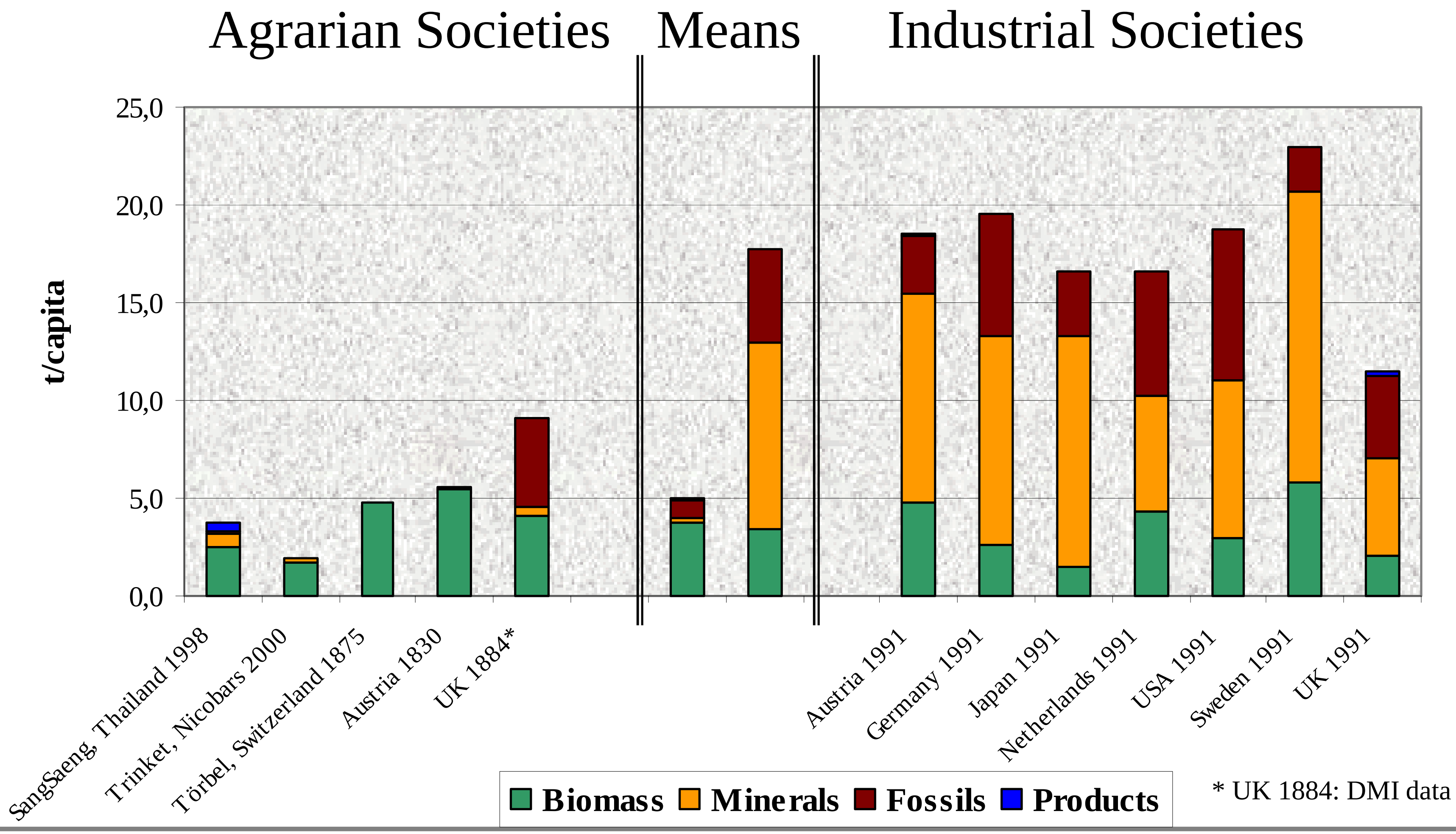
On average 20 - 23% increase in economic material effciency per decade

Metabolic profiles of the agrarian and industrial regime: transition = explosion

		Agrarian	Industrial	Factor
Energy use (DEC) per capita	[GJ/cap]	40-70	150-400	3-5
Material use (DMC) per capita	[t/cap]	3-6	15-25	3-5
Population density	[cap/km²]	<40	< 400	3-10
Agricultural population	[%]	>80%	<10%	0.1
Energy use (DEC) per area	[GJ/ha]	<30	< 600	10-30
Material use (DMC) per area	[t/ha]	<2	< 50	10-30
Biomass (share of DEC)	[%]	>95	10-30	0.1-0.3

Source: Social Ecology DB

Metabolic profiles by sociometabolic regimes (DMC/capita)



* UK 1884: DMI data

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Part 3: Ongoing transitions

- Is „development“ such a transition from an agrarian to an industrial regime?
  - does it follow the same historical trajectory?
  - Does it lead to similar outcomes, that is for example a factor 3-4 increase in material and energy use?
  - What are the relevant framework conditions influencing these transitions? How do they differ from history?
- Is a contemporary industrial metabolic profile possible for all and everywhere?
  - What are indications of local / regional constraints?
  - What are the global constraints?
  - What are the ways out?

Country classification (N=165 countries for the year 2000)

Development status: according to UN classification; differentiation between industrialized countries (incl. Transition Markets) and developing countries (all others; wide range from least developed to newly industrialized countries)

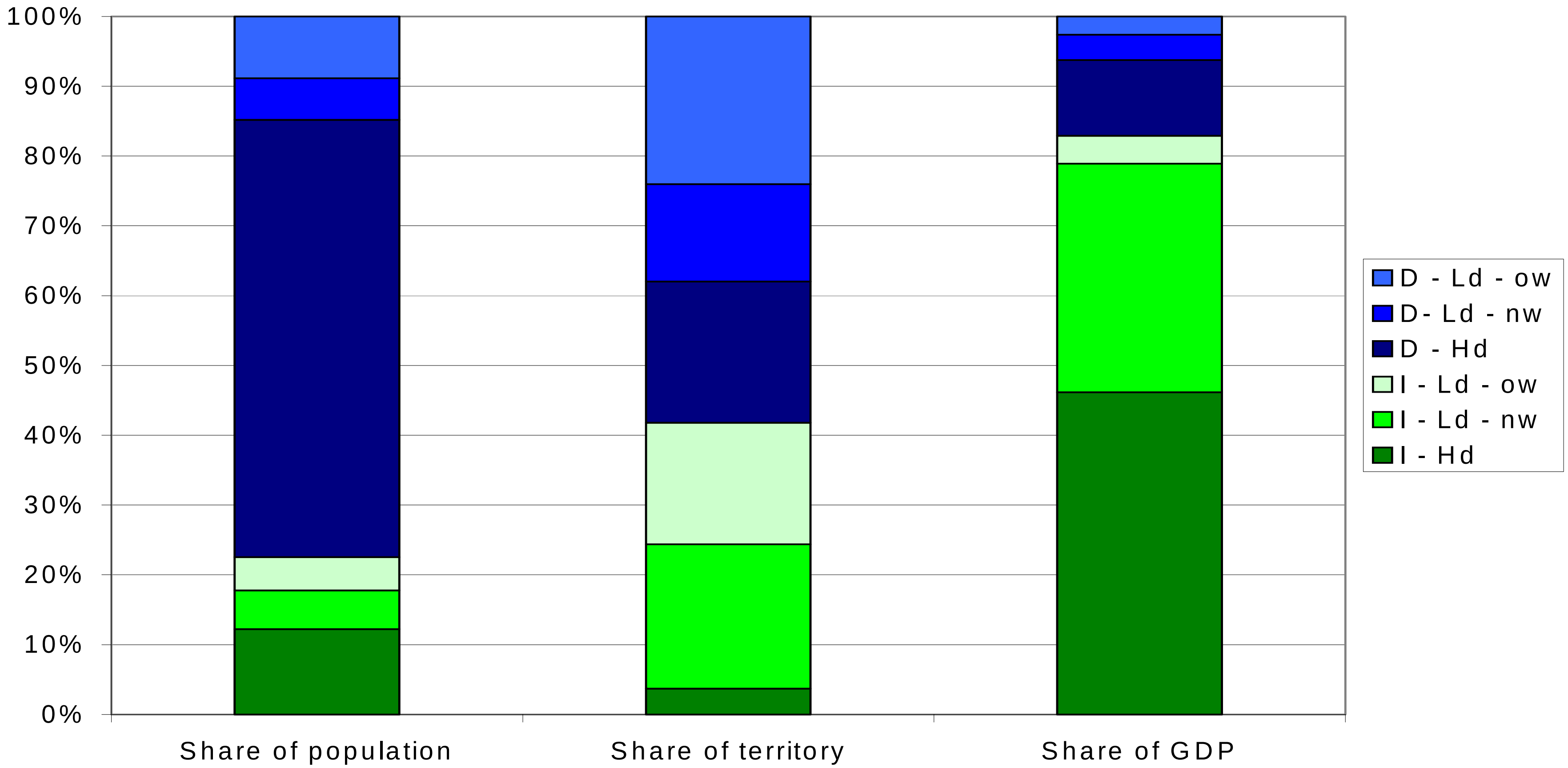
Population Density: low and high density countries (50 persons/km² as dividing line)

Length of history of agrarian colonization: “Old World” countries versus “New World” countries

Country classification (165 countries worldwide, by the year 2000)

	Industrial	Developing
Population density high (>50/km2)	Industrial high density European countries, Japan, South Korea (N=30) **I - Hd**	Developing high density Most of S-E Asia incl. India, China, Central America, some African countries. (N= 65) **D - Hd**
Population density low (<50/km2) NEW WORLD	Industrial low density - new world: North America, Australia, New Zealand. (N= 4) **I – Ld - nw**	Developing low density – new world: South America. (N = 22) **D – Ld - nw**
Population density low (<50/km2) OLD WORLD	Industrial low density – old world: Former Soviet Union, Scandinavian countries. (N = 15) **I – Hd - ow**	Developing low density – old world: Arid countries in Asia and Africa (N = 41) **D – Hd - ow**

Unequal distribution of global resources (for the year 2000)



Transition tracks: Population and Economy (2000)

	Population density [cap/km^2]	Agricultural population [%]	GDP [US$ PPP/cap]
I - Hd	149	9%	18,364
I – Ld - nw	12	2%	30,540
I – Ld - ow	12	14%	6,333
D - Hd	140	56%	2,866
D – Ld - nw	19	19%	6,312
D – Ld - ow	17	52%	2.802
World	45	42%	6,665
China	134	67%	3,491
Australia	2	5%	24,090

Source: Maddison 2002, Social Ecology DB

Metabolic profiles in 2000: Material and Energy use per capita

Conclusion: Factor 2 difference between high and low density countries

	Material use (DMC) per capita [t/cap]	Energy use (DEC) per capita [GJ/cap]	Electricity use per capits [GJ/cap]
I - Hd	15	190	22
I – Ld - nw	29	443	52
I – Ld - ow	14	192	20
D - Hd	6	49	3
D – Ld - nw	15	131	7
D – Ld - ow	6	76	4
World	10	102	9
China	8	75	4
Australia	42	470	40

Source: Maddison 2002, Social Ecology DB

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Source: Maddison 2002, Social Ecology DB

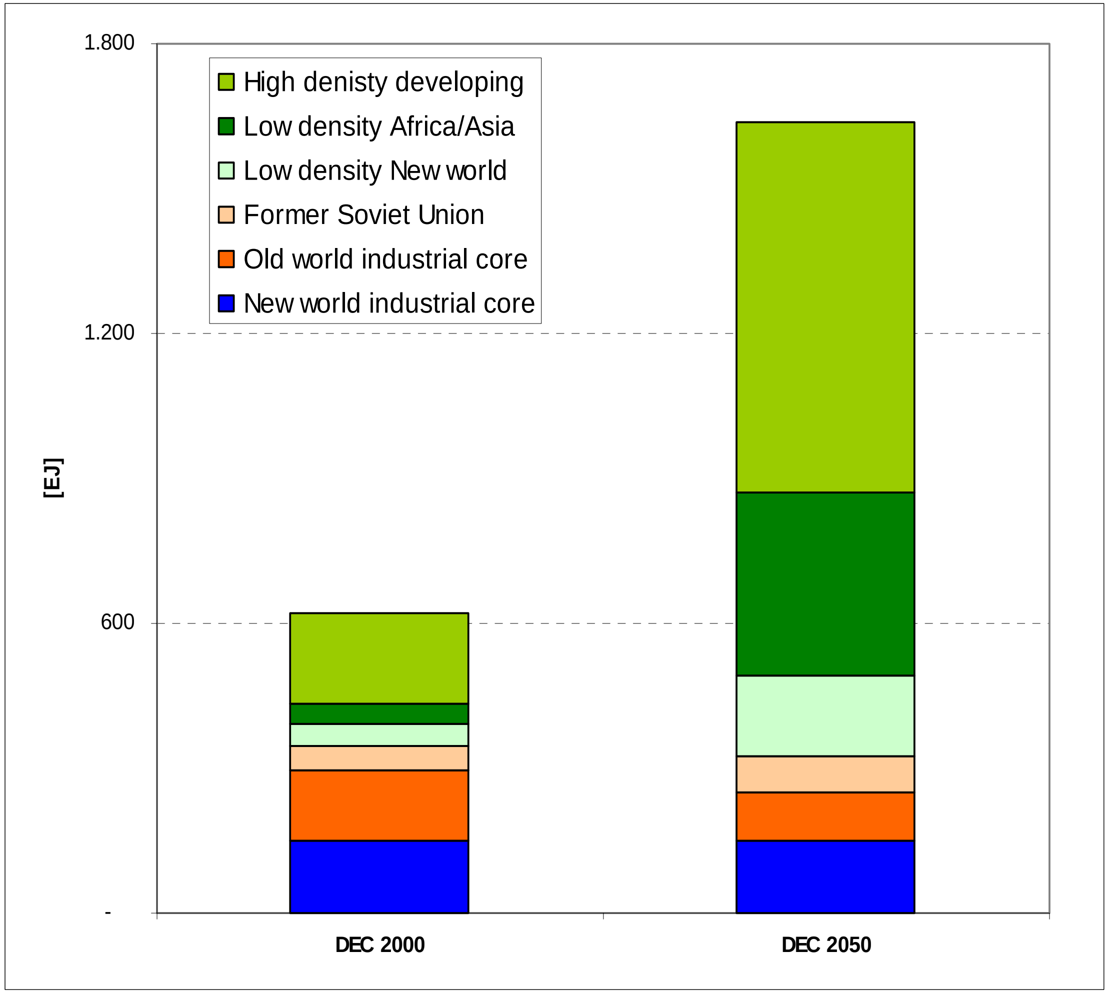
Environmental pressures 2000

Conclusion: Regional environmental pressure already high in high density developing countries

	Energy use (DEC) per ha [GJ/ha]	Material use (DMC) per ha [t/ha]	HANPP appropriated plant energy [%]
I - Hd	284	23	42%
I – Ld - nw	54	4	19%
I – Ld - ow	24	2	15%
D - Hd	69	9	40%
D – Ld - nw	25	3	14%
D – Ld - ow	13	1	15%
World	46	4	22%
China	73	10	38%
Australia	12	1	11%

Source: Maddison 2002, Social Ecology DB

Convergence scenario: World energy consumption (DEC) by the year 2050



Scenario assumptions for the year 2050

Developing countries:

Achieve the same p/c energy consumption as industrial countries of same density class

Industrial countries:
p/c energy consumption of 2000 – 30%
(high density: 135 Gj/cap, low density: 310 Gj/cap)

Additional factor explaining variation within regimes: population density

- High population density is associated with lower resource use (about factor 2), but the relationship remains complex.
  - If there are few resources, such as very arid land or cold climate, there is a limit to the number of people that can be sustained under agrarian conditions (>low density + low resource consumption)
  - If a few people come to a rich environment, such as to a newly conquered continent, they will generously consume (>low density + high resource consumption).
  - If many people populate a rich environment, resources will become scarce, but each person will need less for a good standard of living because of economies of scale (>high density + low resource consumption)