United Nations Nations Unies

ECONOMIC ANALYSIS AND POLICY DIVISION
DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS

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Energy transition and the transition of current modelling practices

Switching to a deepened structural framework is a prerequisite for understanding radical transformations

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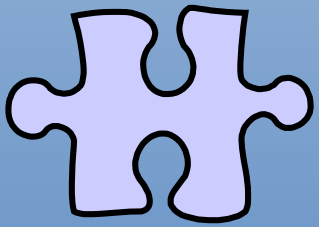
WIFO

Wegener Center

UNI GRAZ



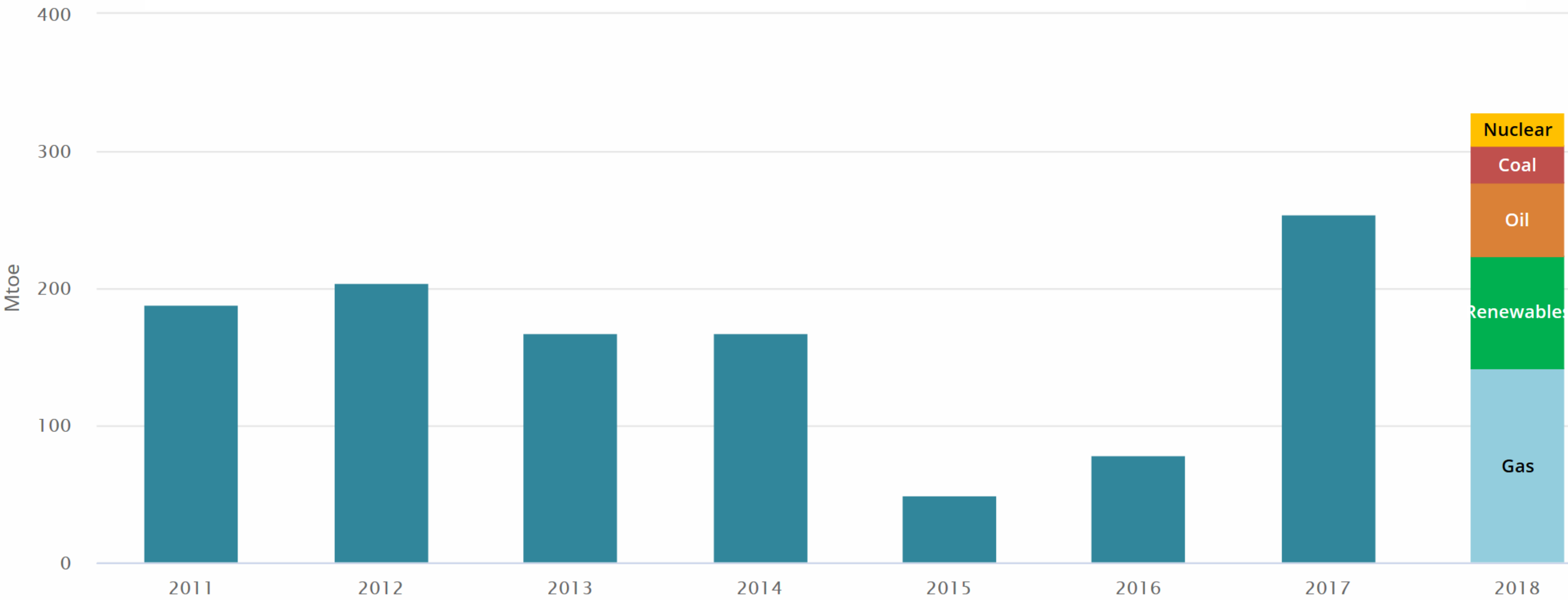
Recent evidence about energy and emissions

Current trajectories are way-off from the Paris Agreement requirements

2019 Global Energy and CO_2 Status Report

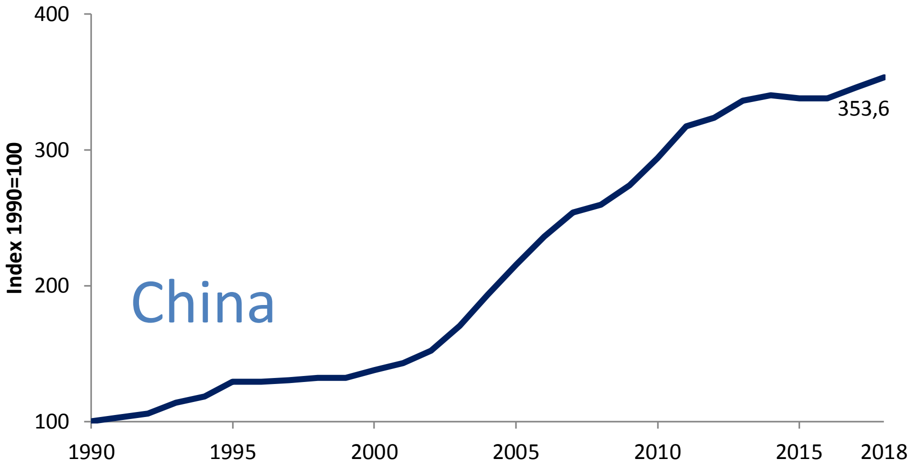
International Energy Agency

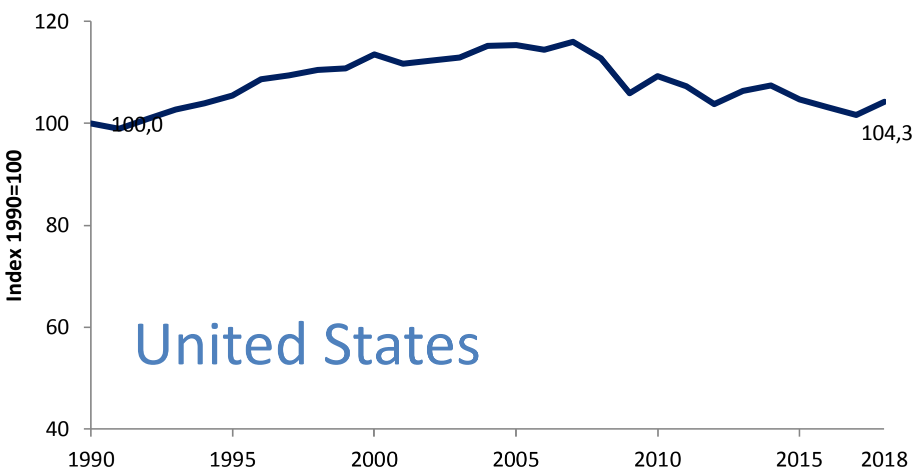
Annual change in global primary energy demand 2011 - 2018

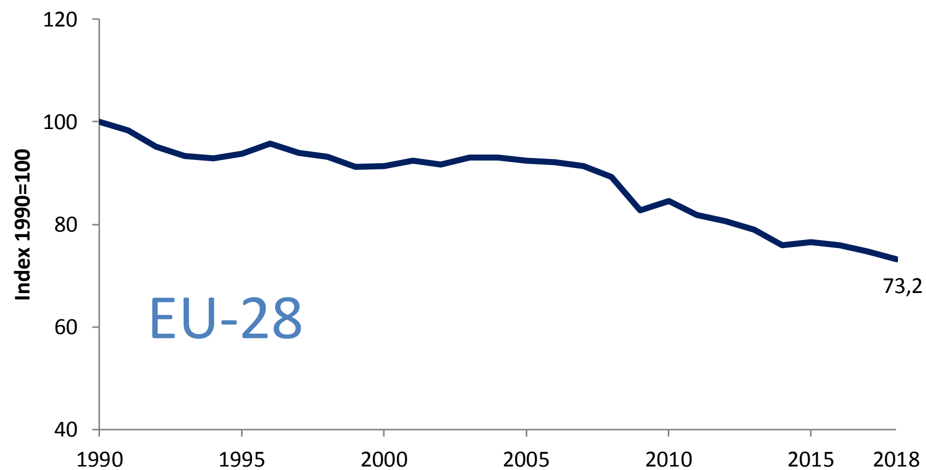


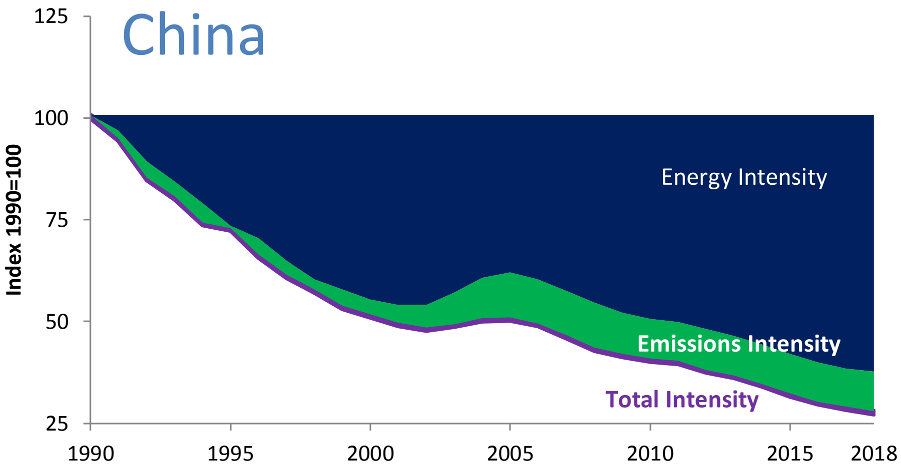
https://www.iea.org/geco/

Big emitters
GHG emissions







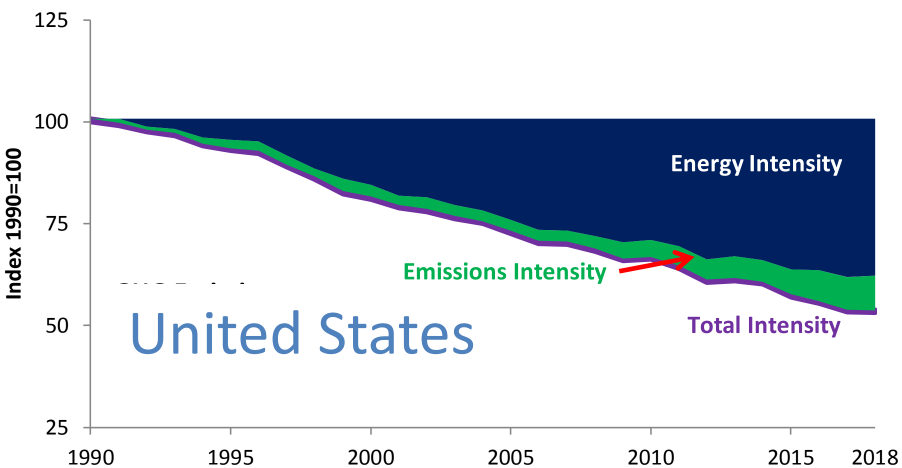


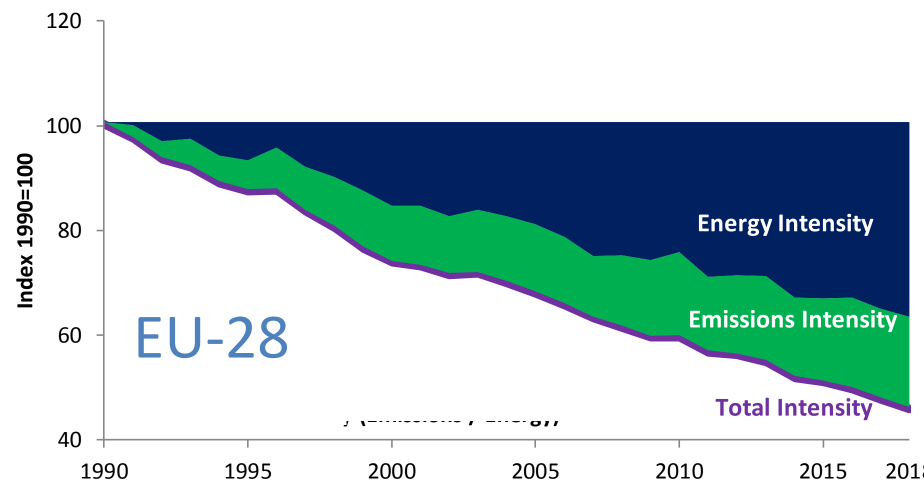
Big emitters
Total emissions intensities

Energy intensity
= energy / GDP

Emissions intensity
= emissions / energy

Total intensity
= energy / GDP





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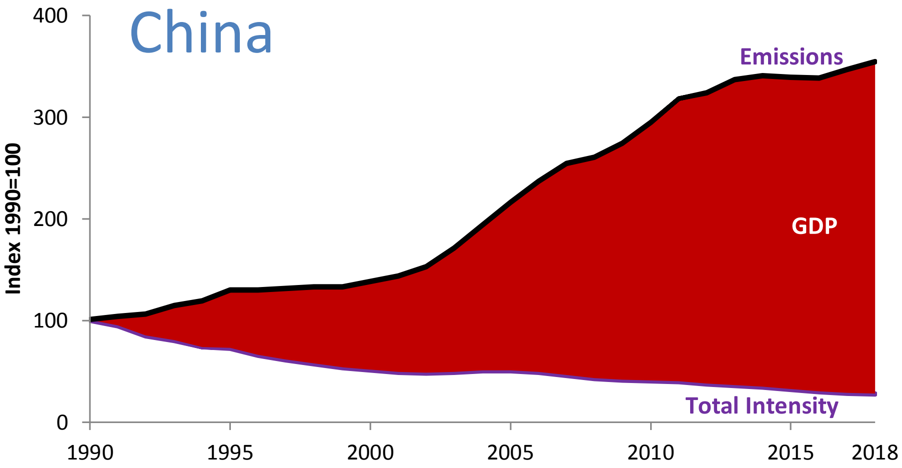
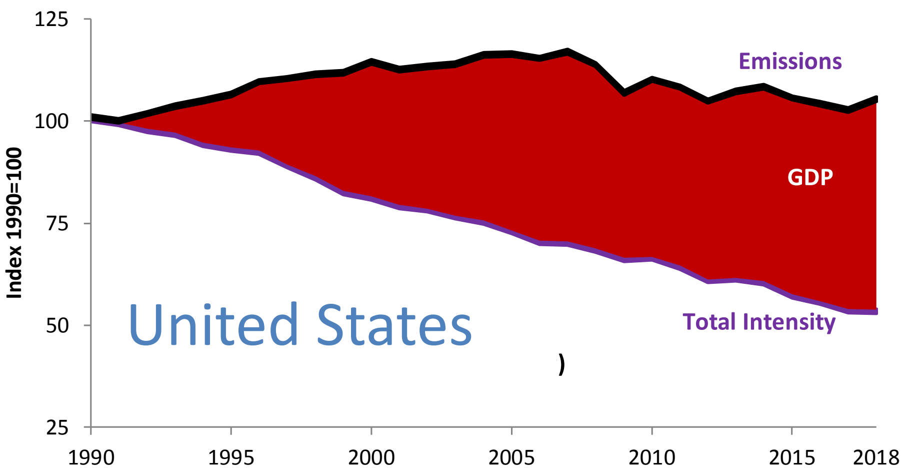
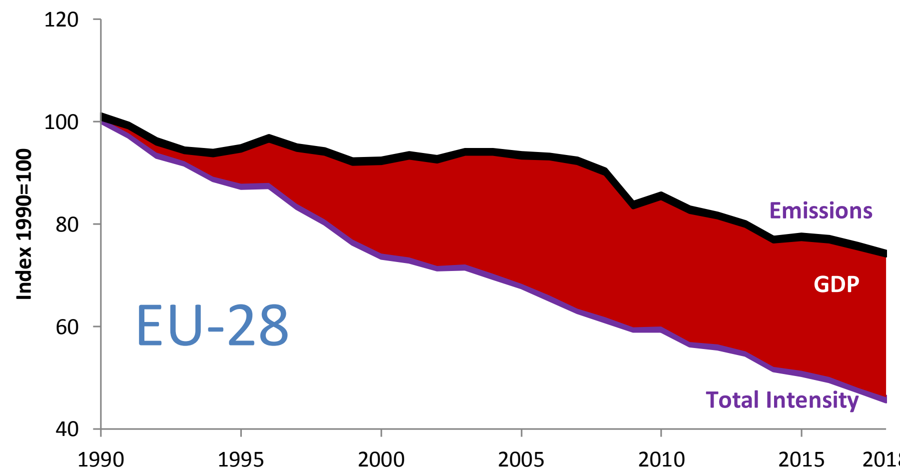
Big emitters
GDP impact

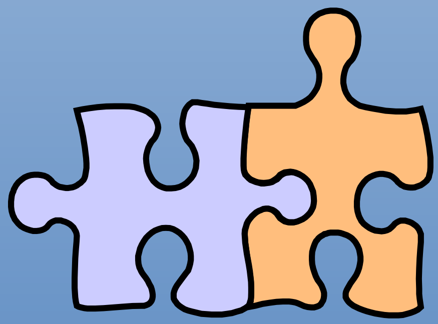


Emissions

= total intensity * GDP





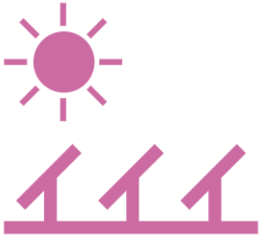


How low-emissions energy systems might look like

There is more to be considered than renewables and e-vehicles

The Suurstoffi project in Switzerland

The zero-emissions energy concept



Solar energy

Electric and thermal solar components

Anergy thermal grid

Low temperature thermal grid with heat pumps for recycling heat

Thermal storage

Thermal storage for heating and cooling in buildings and underground

Learning from the Swiss project NEST at EMPA
Exploring the future of buildings

The basic structure

A platform for innovative construction technologies

Urban mining & recycling unit

A residential module fully constructed from reusable, recyclable, and compostable materials.

Explores to advance the construction industry's transition to a recycling economy.

Light-weight floor elements

for self-supporting concrete floors for skyscrapers

need no steel reinforcement

70% lighter than conventional floors

prefabricated

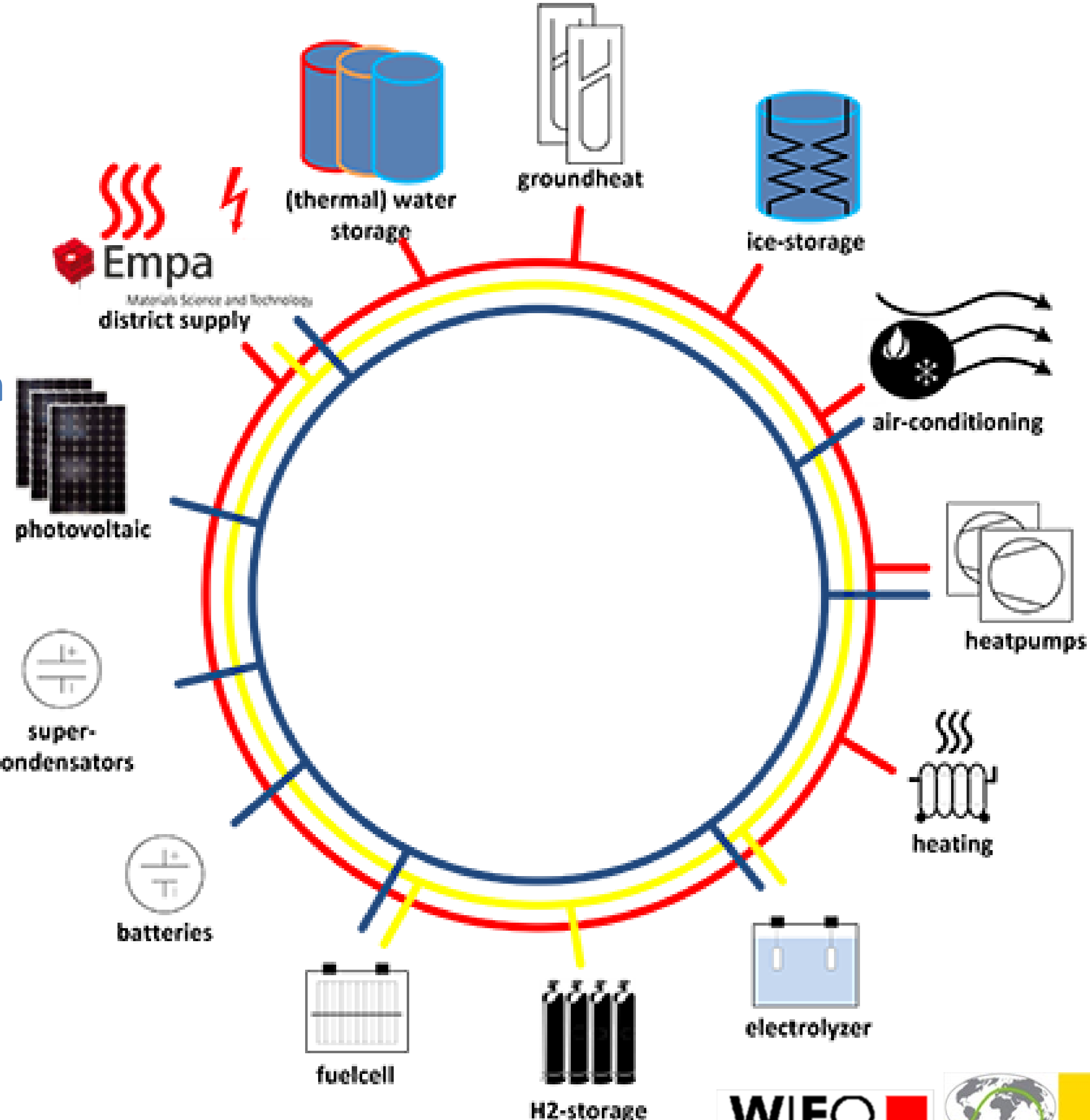
integration of infrastructure for heating and cooling

serve as a thermal storage

Energy Hub

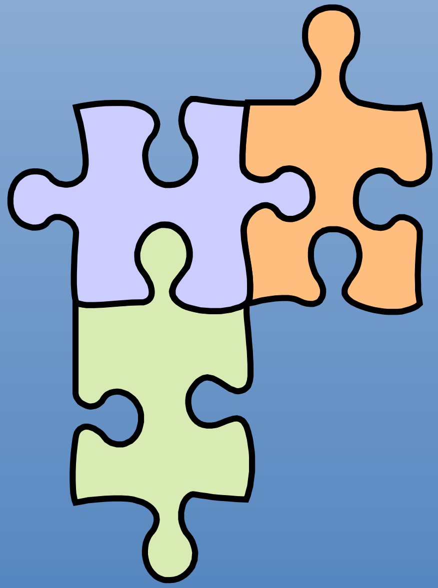
- Four grids connect all components of the energy system
    - Electricity
    - Heating/Cooling
    - Gas
    - IT

    - Interdependent
    - bi-directional



A lesson from the ongoing H2FUTURE project
Exploring steel making with hydrogen

- Potential need for carbon-free electricity
  - up to half of total current electricity consumption in Austria
  - We obtain similar insights from other energy intensive industries
- It is inconceivable to replace current volumes of fossils in energy intensive industries with renewables



In a nutshell:
The building blocks for
a deepened structural energy modeling approach

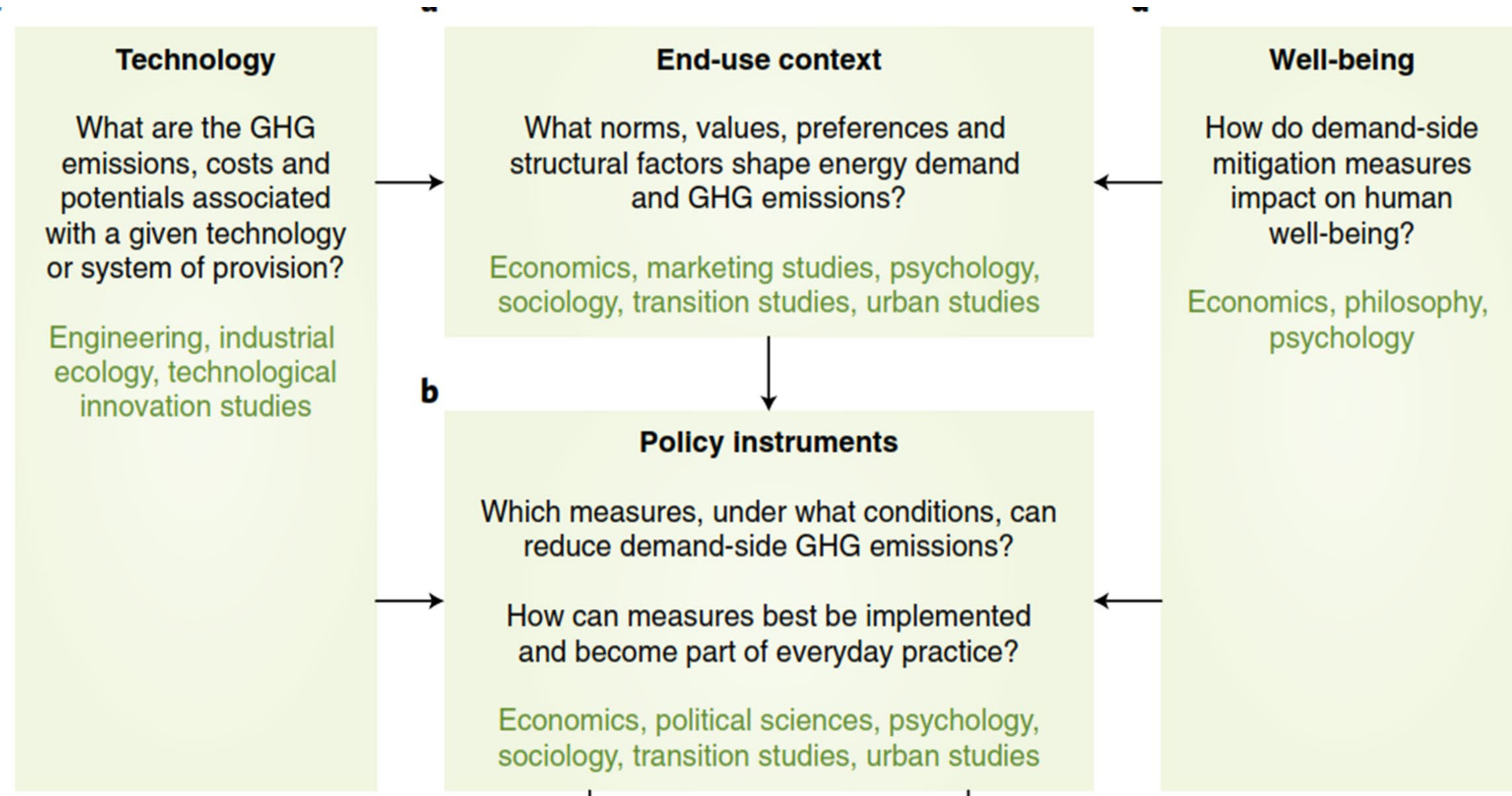
Why (most) conventional modelling approaches
are not adequate for dealing with
radical transformations

Controversies about energy modeling
Questioning the model outcomes

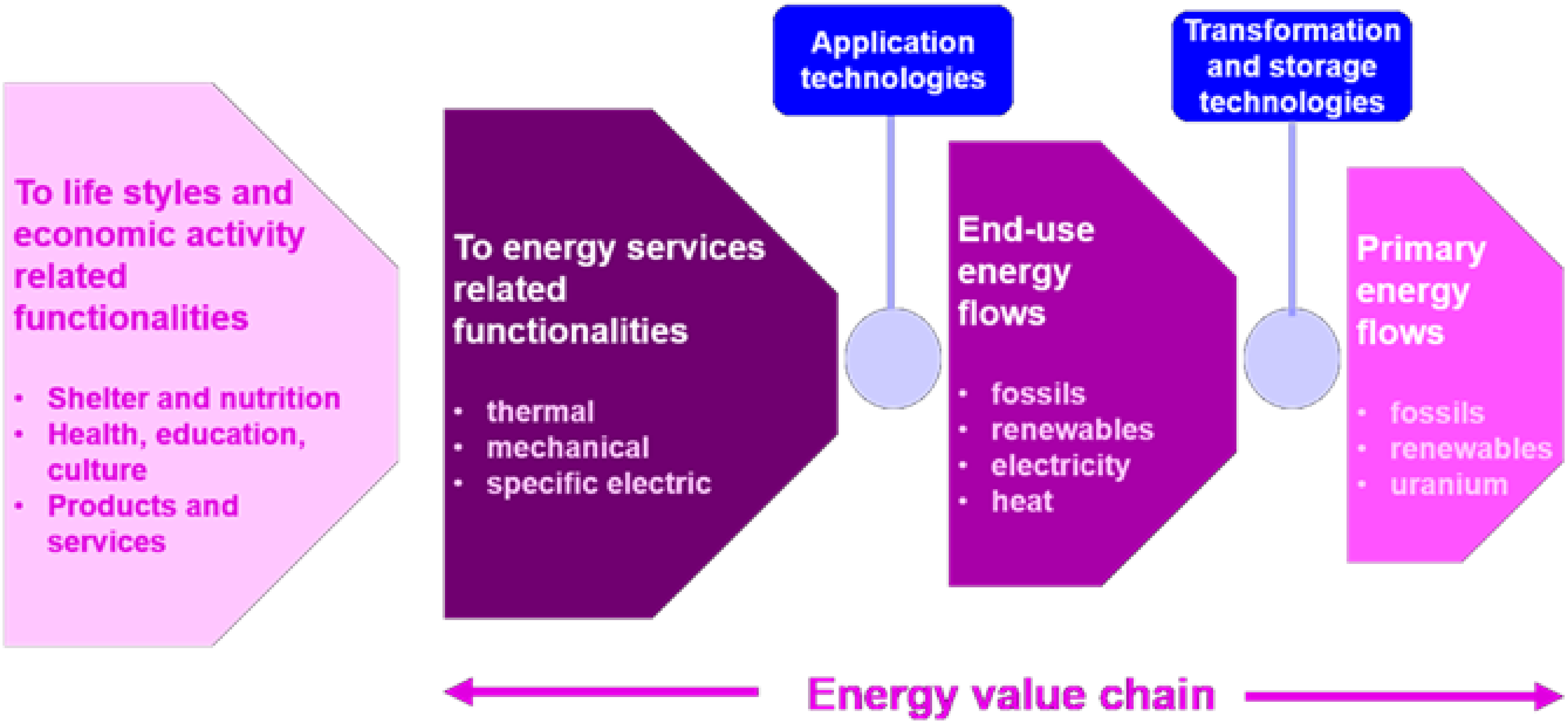
- David Victor, UC San Diego, 2015
  - "IPCC is becoming irrelevant to climate policy"
- A damaging statement of Working Group III is undermining the reputation of IPCC (2014)
  - "Annual economic growth might decrease by just 0.06 (!) percentage points by 2050 if governments were to adopt policies that cut emissions in line with the widely discussed goal of 2°C above pre-industrial levels".

The new challenges for energy modeling

Towards demand-side solutions for mitigating climate change. Nature Climate Change (2018)



Deepened structural specifications
The basic design



Tier 1:
The physical layer

Step 1

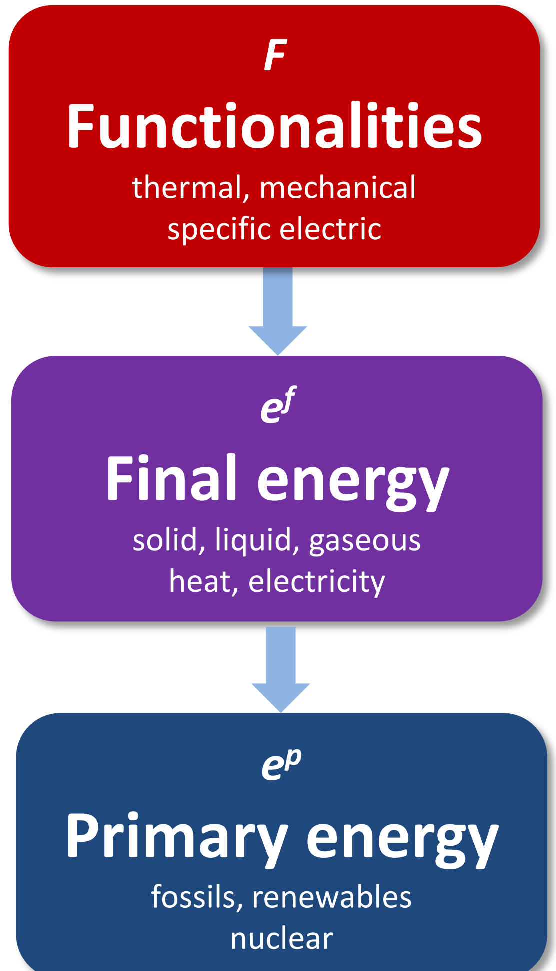
Identify energy services

The functionalities of an energy system

- Thermal functionalities
  - low temperature (buildings)
  - high temperature (industry)
- Mechanical functionalities
  - stationary (engines)
  - mobile (transport)
- Specific electric functionalities
  - lighting
  - electronics

Step 2

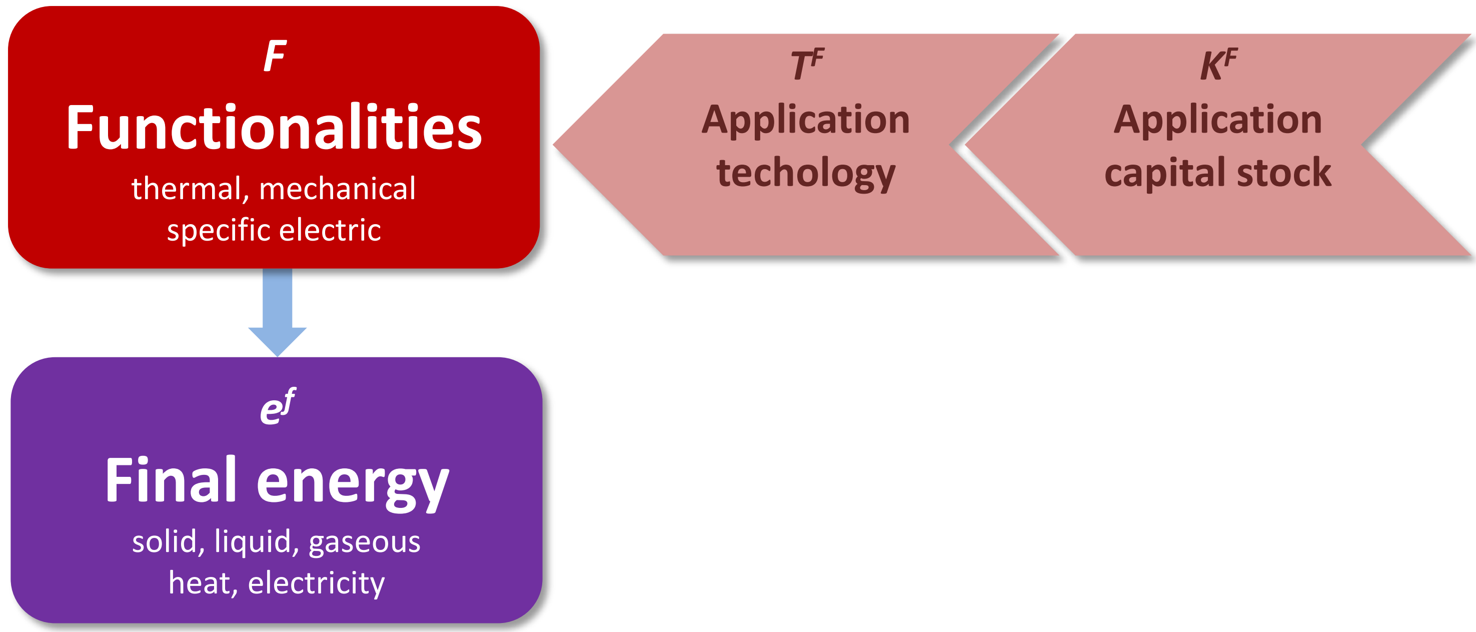
Consider the full energy value chain



Step 3

Identify physical interactions with capital stocks

Functionalities and final energy – application technologies

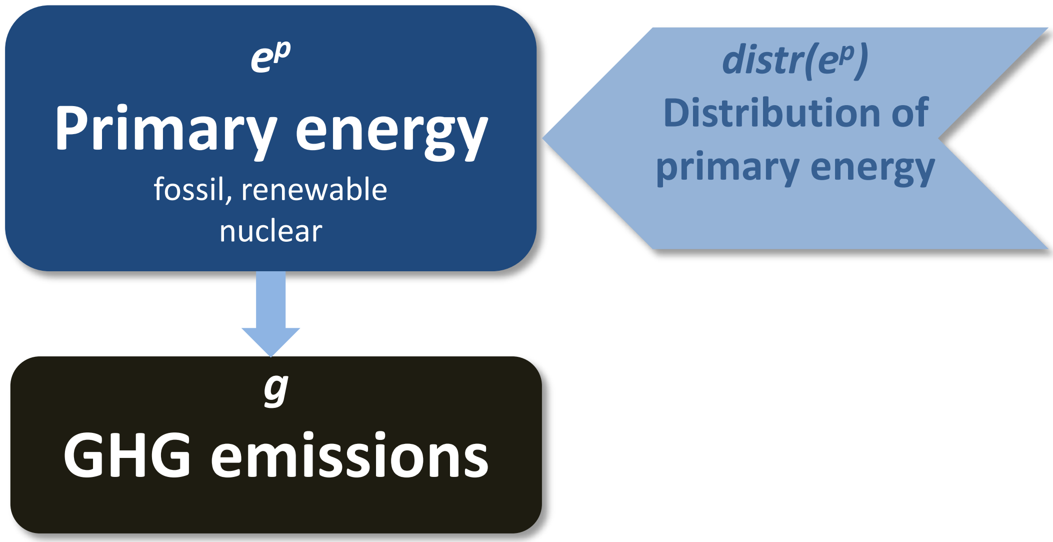


$$F = T^F(e^f, K^F)$$
$$e^f = t^F(K^F)^{-1} \cdot F$$

Step 4

Link emissions to primary energy

Emissions intensities depend on fuel mix

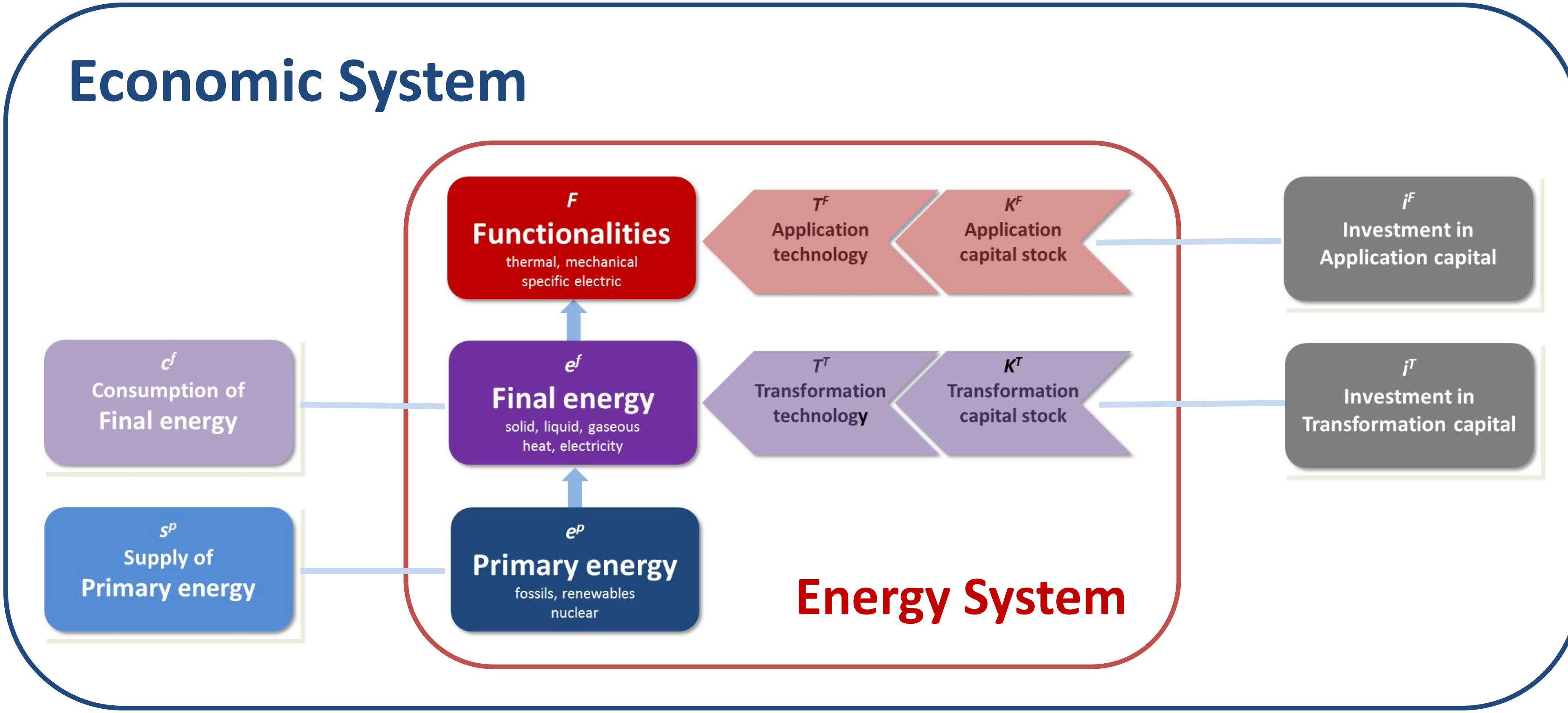


$$g = g^{fos}(distr(e^{p,fos}))\cdot(1 - s^{p,fos} - s^{p,res} - s^{p,nuc})\cdot e^p$$

Tier 2:
The economic layer

Step 5

Identify interactions with the economic system



The energy system interacts with the economic system vial the consumption of energy and investments into application and transformation technologies

Tier 3:
Markets and institutions

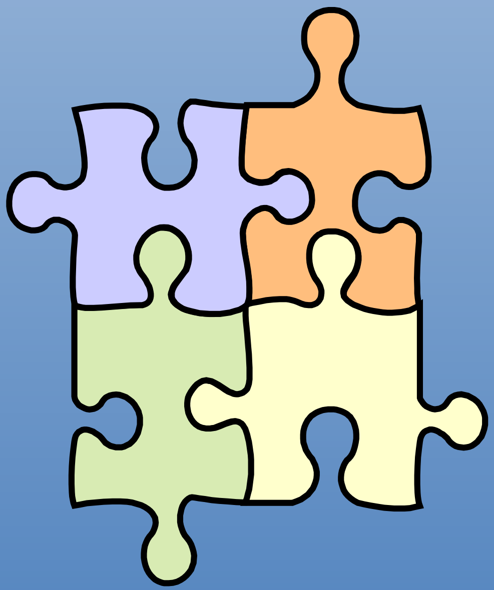
Step 6

Add mechanisms for coordination and incentives

- **This modeling design deliberately separates the analysis of structures from mechanisms that generate these structures**

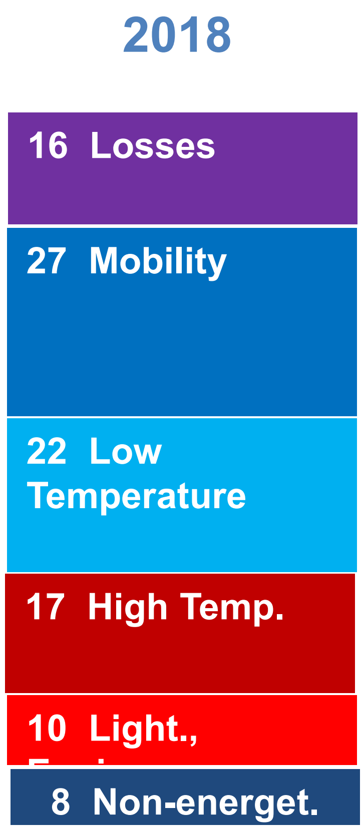
- **Price-determined mechanisms**
  - **if prices are relevant**

- **Non-price determined mechanisms**
  - **standards and other regulations**



Implementing this
deepened structural modeling approach

A deepened view on energy systems



Changing the questions

So far: Where from
can we get plenty and cheap energy

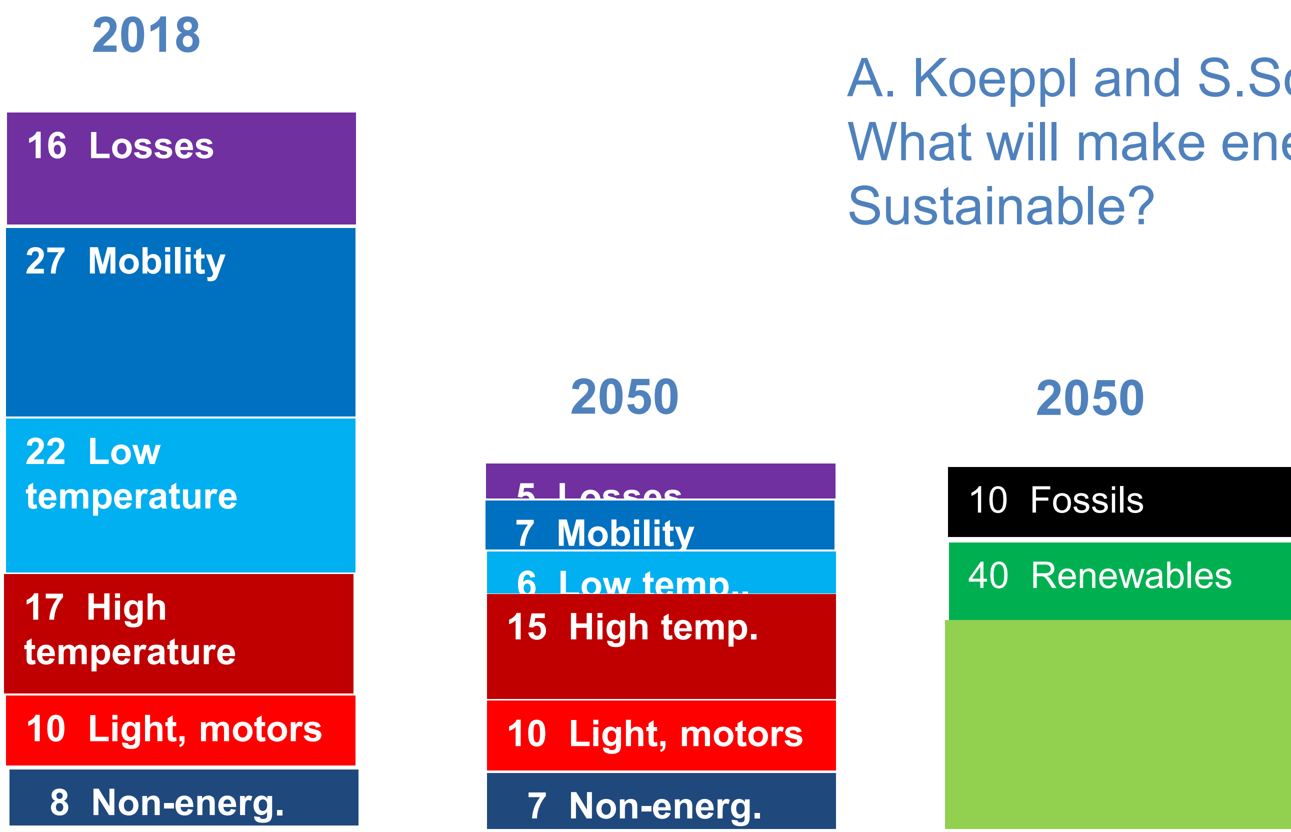
Now: What for
do we need energy

The transition to low-energy structures

A low-carbon energy system for 2050 or earlier

https://**ergyfutures.net**

A. Koeppl and S.Schleicher (2018)
What will make energy systems Sustainable?



The evolution of our understanding, modelling and policies of energy systems

Level 1
Renewables

Substitution of fossils by renewables

Level 2
Efficiency

Isolated improvements of energy efficiency

Level 3
Innovation, integration, inversion

Discovering synergies in the energy system

Level 4
Materials, processes, products

Supply chains from materials to products

Thank you.

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