

# Post-carbon energy paradigms: 2050 and beyond

Patrick Criqui

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and Sustainable Economic Growth

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***Introduction: energy and carbon foresight***

***Vision of the 2050 horizon: the Secure project***

***Beyond 2050: US-CCSP and EU-ADAM scenarios***

***Lifestyles, technologies and land/urban planning***

***Preparing the second half of the XXI<sup>st</sup> century***



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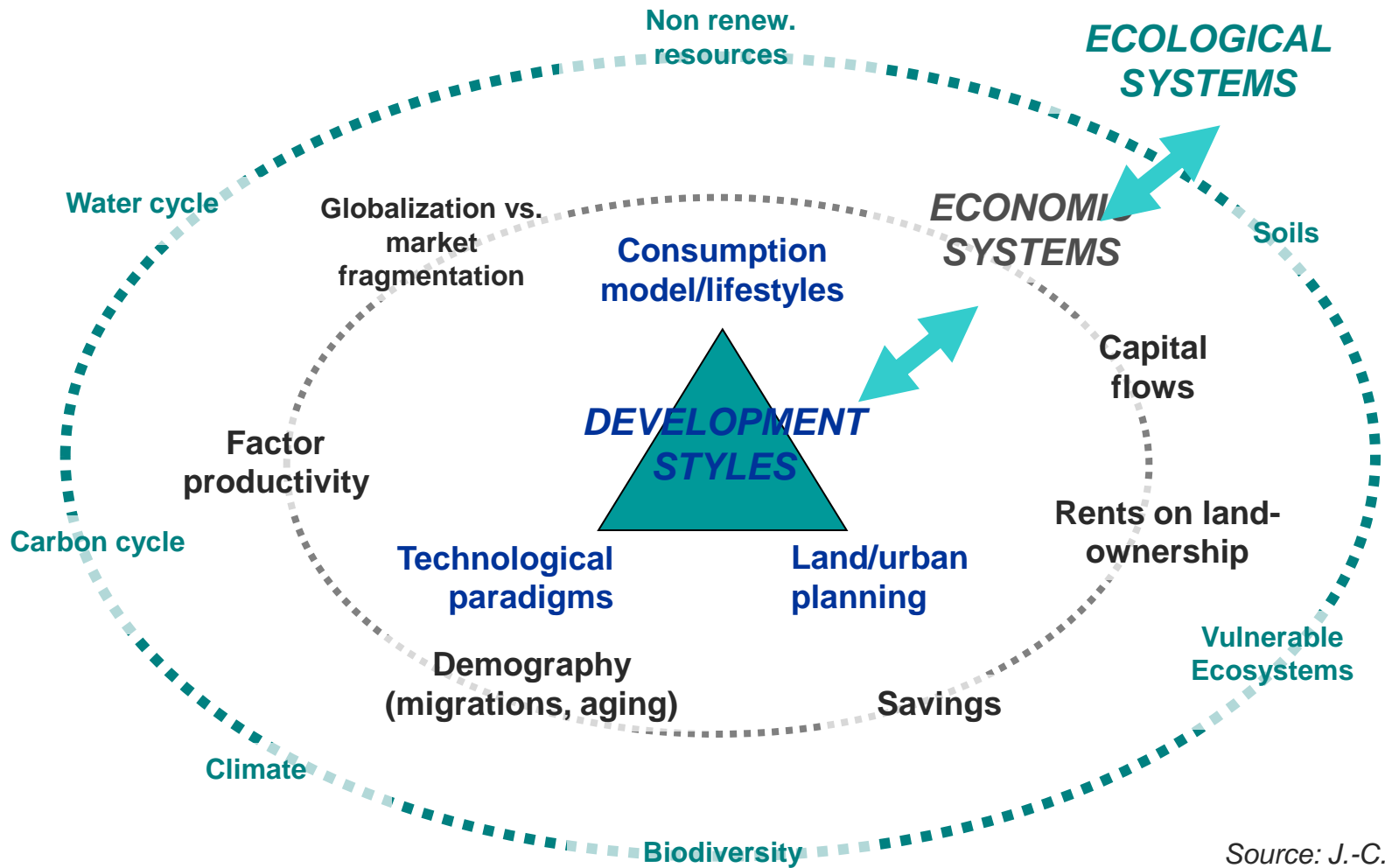
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# Models and scenarios: how to describe complexity?



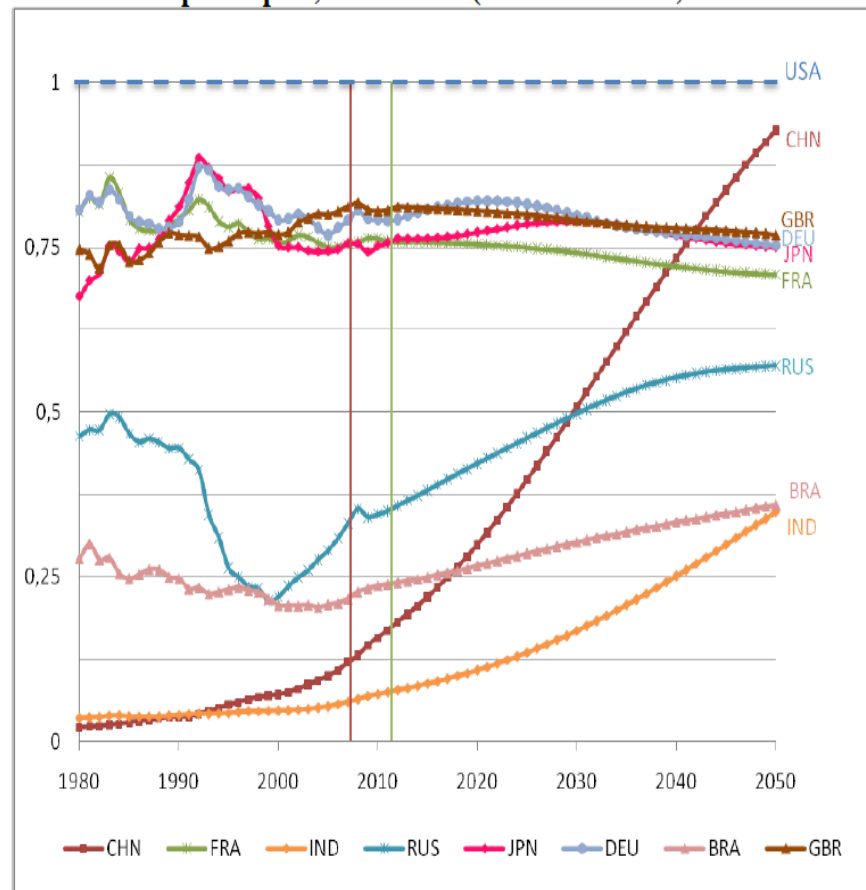
Source: J.-C. Hourcade



# The « Great Convergence »

- ◆ CEPII's economic projection to 2050 for world GDP: 148 T\$ in 2050 / 48 in 2010
- ◆ The catch-up of China with the US might be almost achieved in 2050, with Europe overtaken by 2040 (also see Robert Fogel's forecasts)...
- ◆ This, notwithstanding a pervasive international crisis or political collapse in China

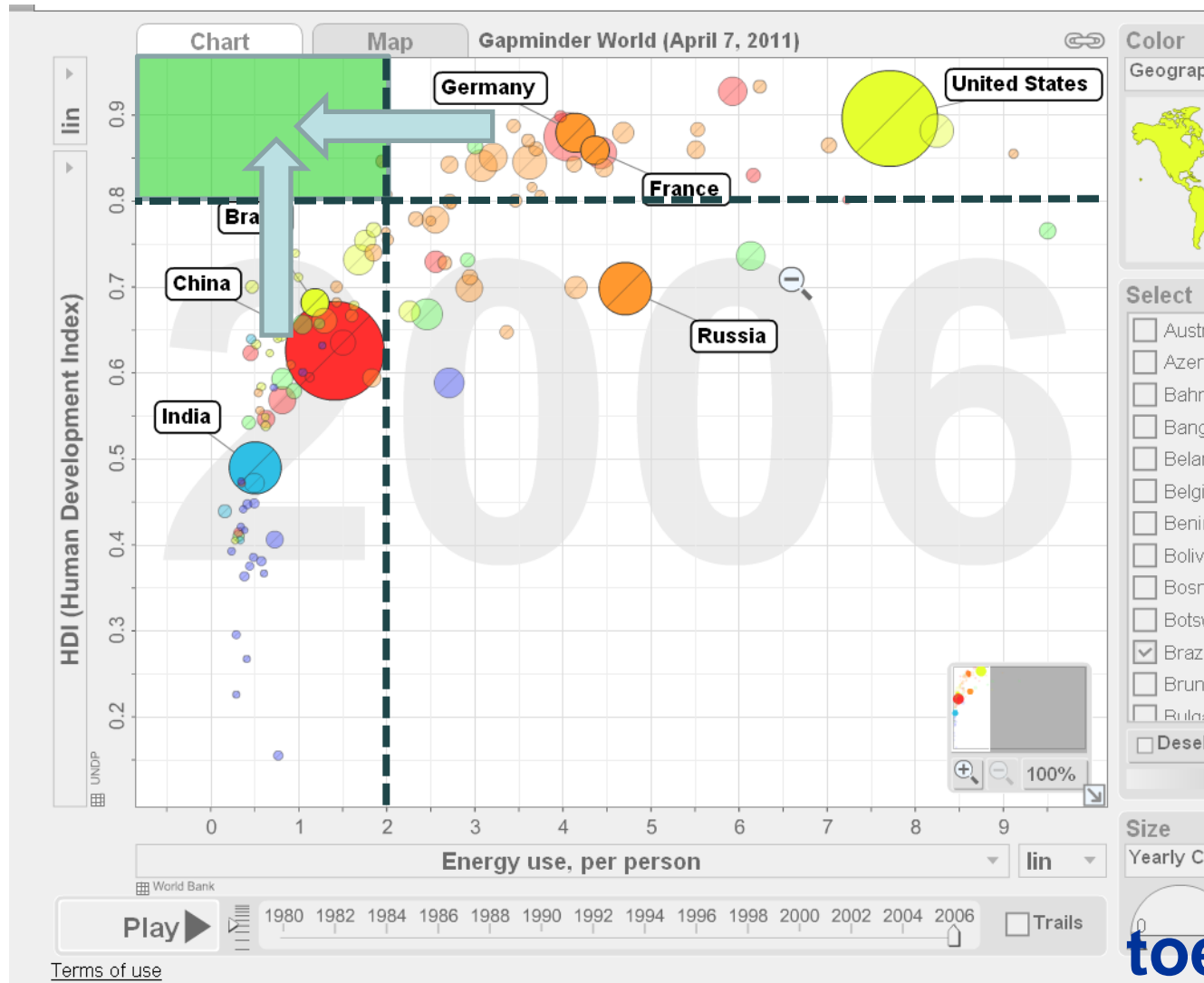
Figure 25 – GDP per capita, 1980-2050 (2005 PPP USD, in % of USA level)



Source: Jean FOURE, Agnès BENASSY-QUERE & Lionel FONTAGNE (2010), The world economy in 2050: a tentative picture, CEPII Working paper 2010-27

# The « window of sustainability »: what great convergence ?

HDI

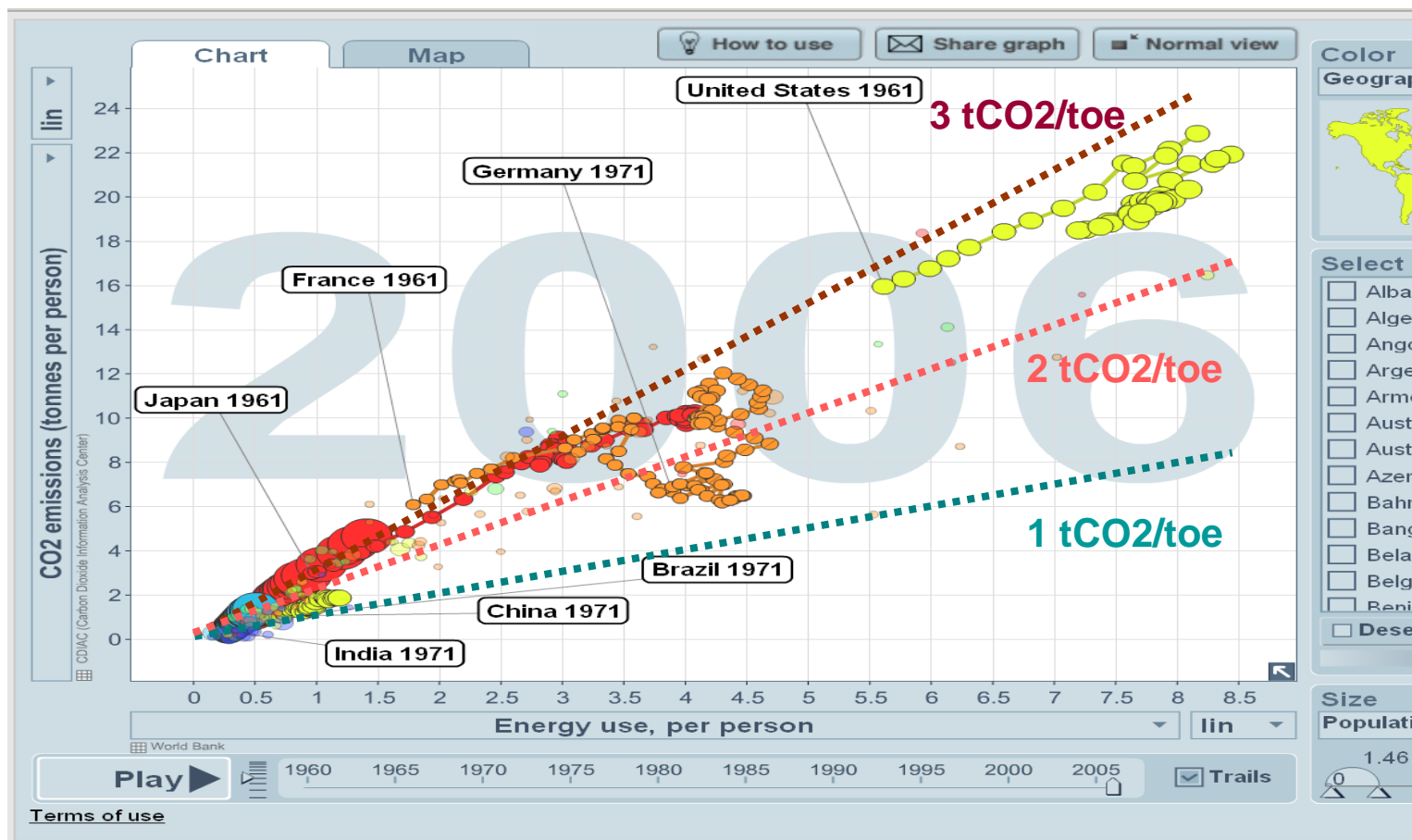


toe/cap



# Reducing the Carbon intensity of energy is a must !

- ◆ With 9 billion people and an average 2 toe/cap (i.e. 18 Gtoe/yr) going below 18 GtCO<sub>2</sub>/yr for energy would still require a major effort of CCS and of decarbonisation of the fuel mix



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# FP7 Secure project: Security of Supply and Climate Policy

## ◆ Scenarios

1. The **BaseLine** case is a counter-factual, no climate policy scenario, used mostly for benchmarking
2. The **Muddling Through** scenario describes the consequences of non-coordinated, low profile climate policies
3. The **Europe Alone** case represents the outcome of a scenario in which only the European Union commits to strong targets (-80%)
4. The **Global Regime** explores a new world energy system, under strong emission constraint, consistent with the 2°C target

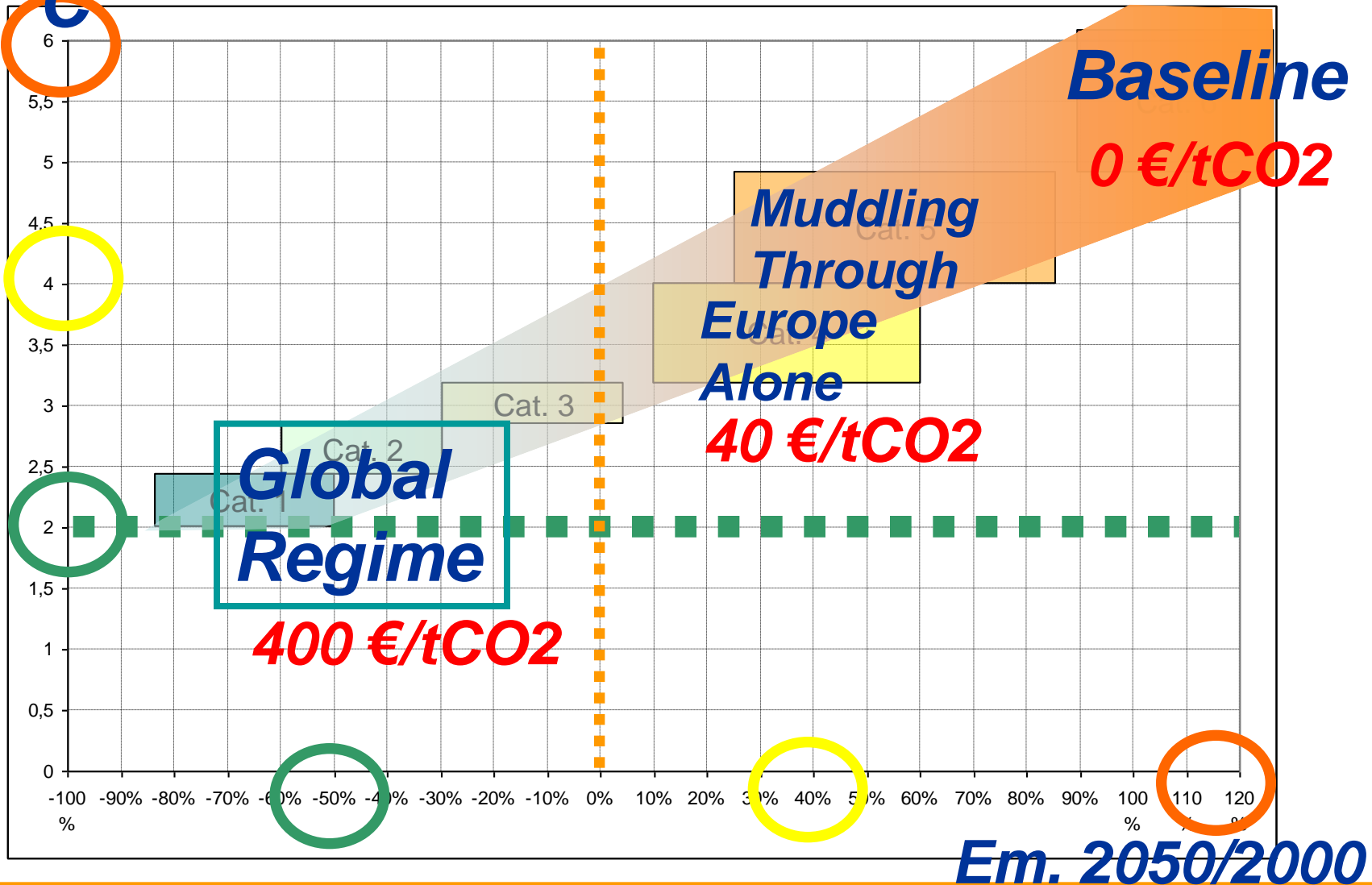
## ◆ Sensitivity studies and shocks

1. Oil and gas shocks
2. Major nuclear accident + phase out
3. Delayed industrial take-off for CCS



# Secure scenarios viewed from SPM T5 of IPCC-AR4

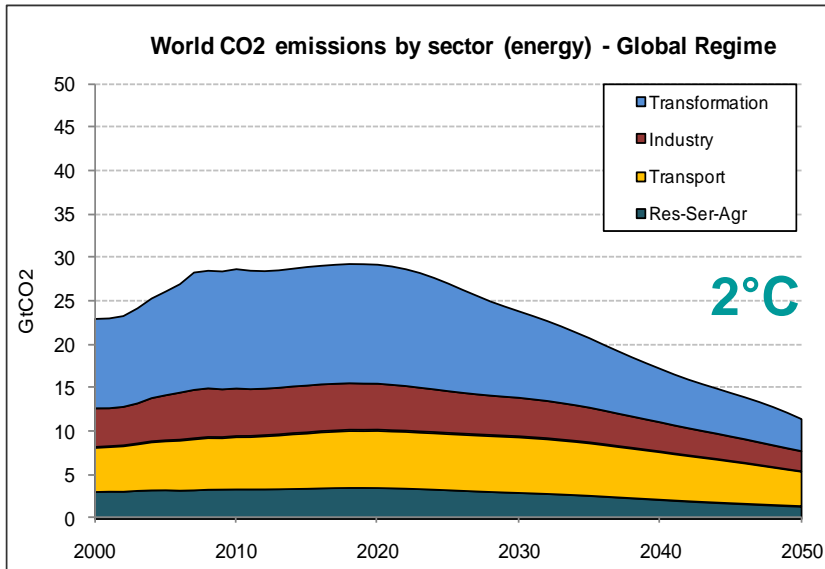
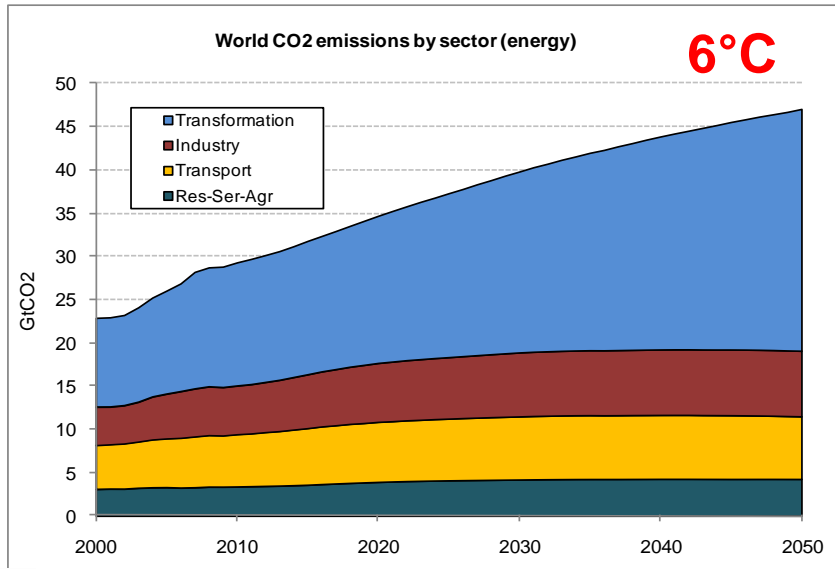
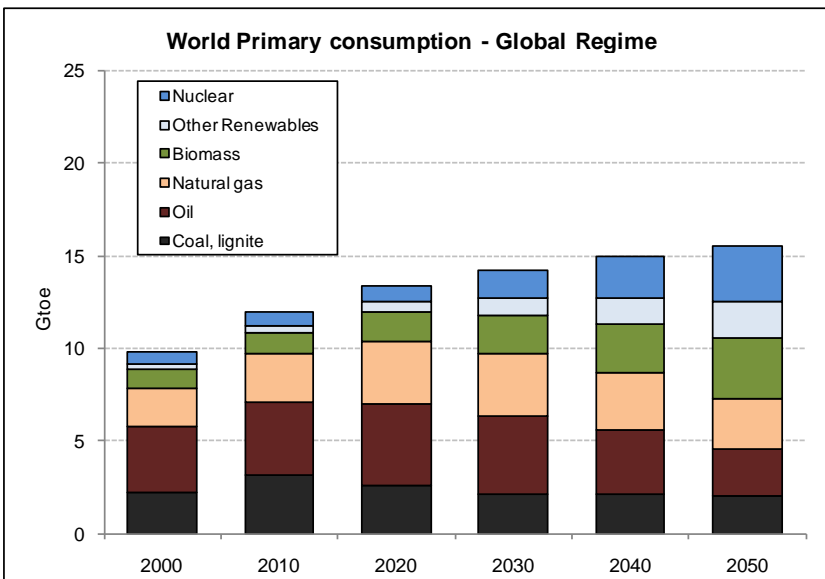
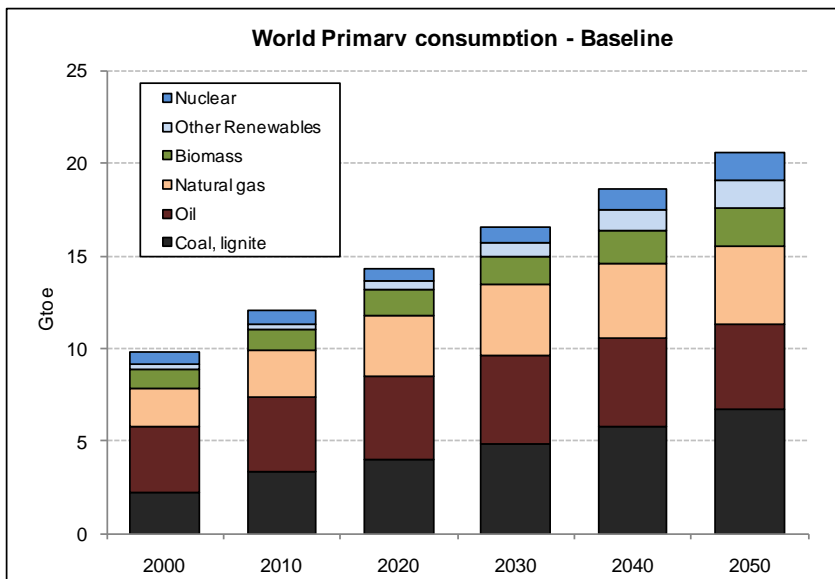
$\Delta T^{\circ}C$



**Em. 2050/2000**



# Two extreme scenarios up to 2050



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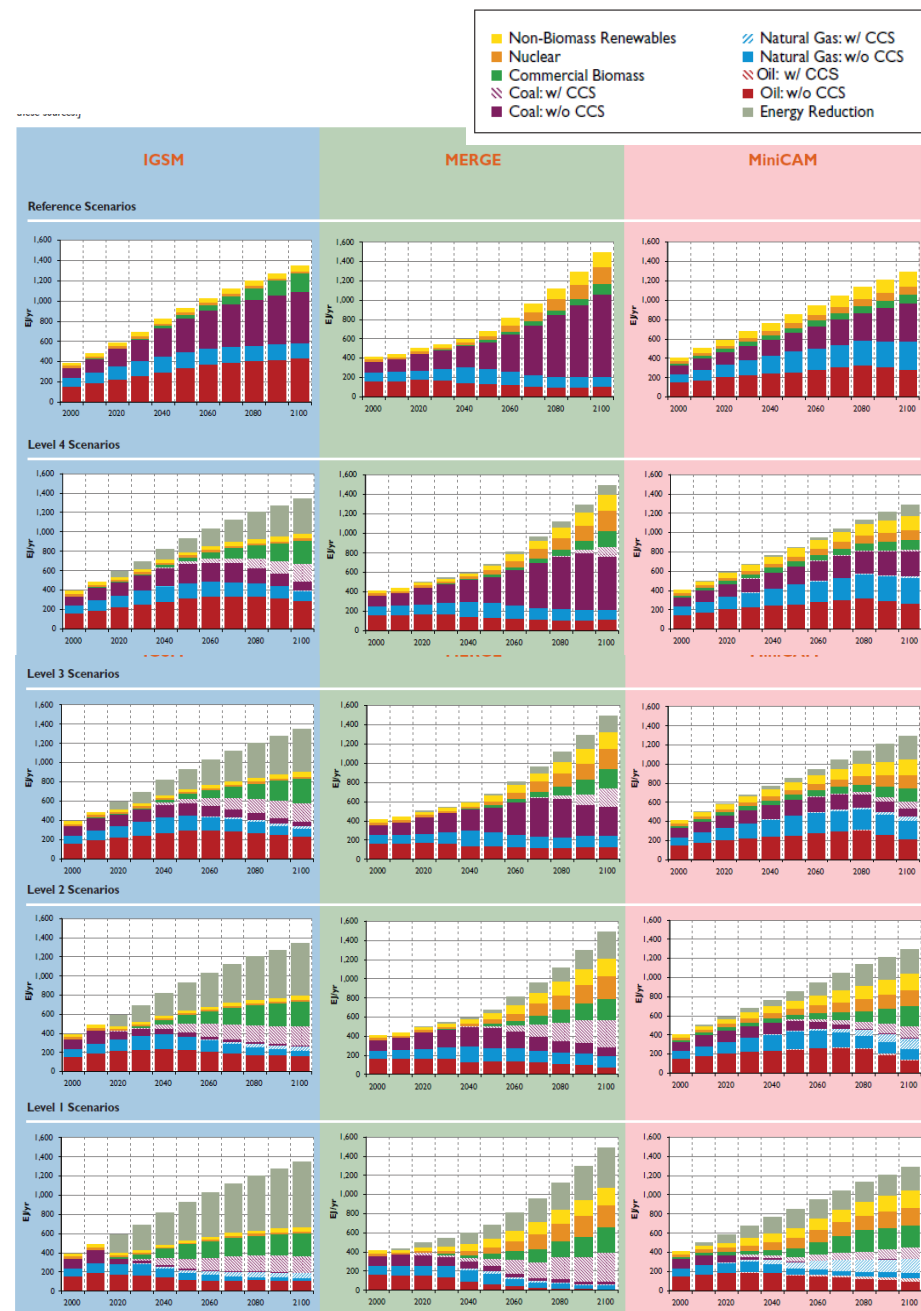
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# US-CCSP, July 2007

- ◆ The US-CCSP allowed to simulate world energy development in the XXI<sup>st</sup> century, with three IAM models and for 5 scenarios
- ◆ Results show a wide range of possible futures (?)

	Total Radiative Forcing from GHGs in this Research (W/m <sup>2</sup> )	Approximate Contribution to Radiative Forcing from non-CO <sub>2</sub> GHGs (W/m <sup>2</sup> )	Approximate Contribution to Radiative Forcing from CO <sub>2</sub> (W/m <sup>2</sup> )	Corresponding CO <sub>2</sub> Concentration (ppmv)
Level 1	3.4	0.8	2.6	450
Level 2	4.7	1.0	3.7	550
Level 3	5.8	1.3	4.5	650
Level 4	6.7	1.4	5.3	750
Year 1998	≈ 2.1	0.65	1.46	365
Preindustrial (1750)	—	—	—	278



# ADAM, FP7 July 2008

- ◆ Similarly the ADAM project explores 3 scenarios with 4 models
- ◆ It also shows a wide range of solutions...
- ◆ and focuses on the necessary conditions for very low stabilization cases (CCS, biomass and renewables)

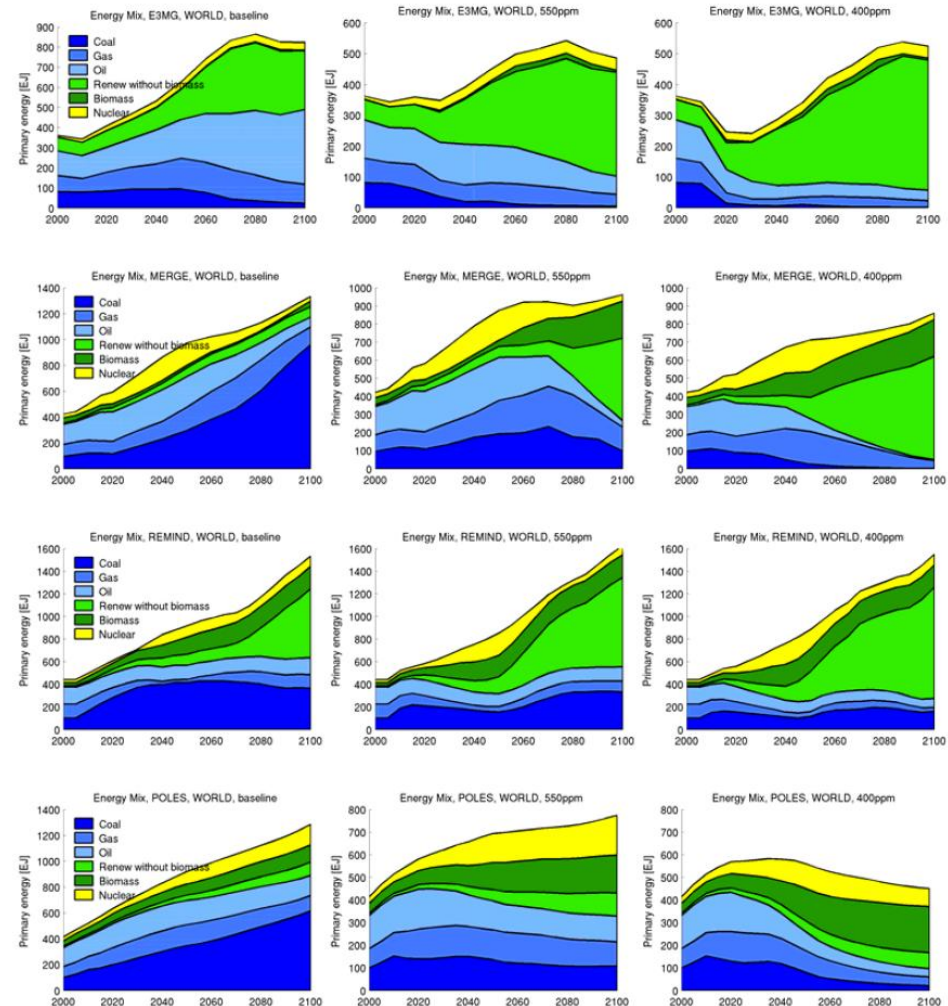


Figure 17: Energy mix for baseline, 550ppm and 400ppm (from left to right) for the different models (from top to bottom: E3MG, MERGE, REMIND, POLES).

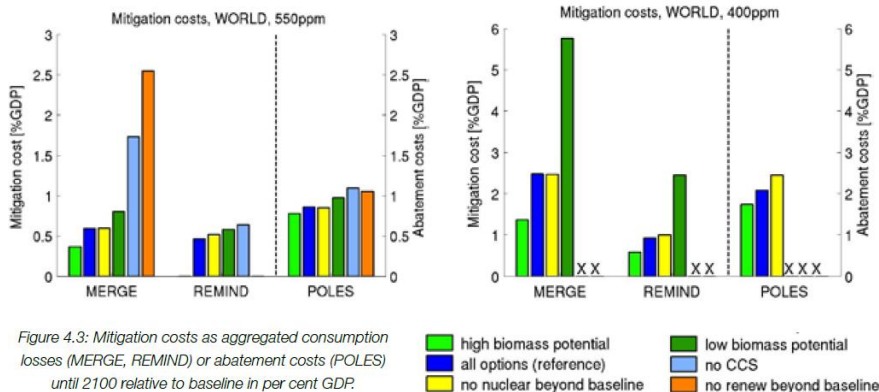


Figure 4.3: Mitigation costs as aggregated consumption losses (MERGE, REMIND) or abatement costs (POLES) until 2100 relative to baseline in per cent GDP.

■ high biomass potential  
■ low biomass potential  
■ all options (reference)  
■ no nuclear beyond baseline  
■ no CCS  
■ no renew beyond baseline



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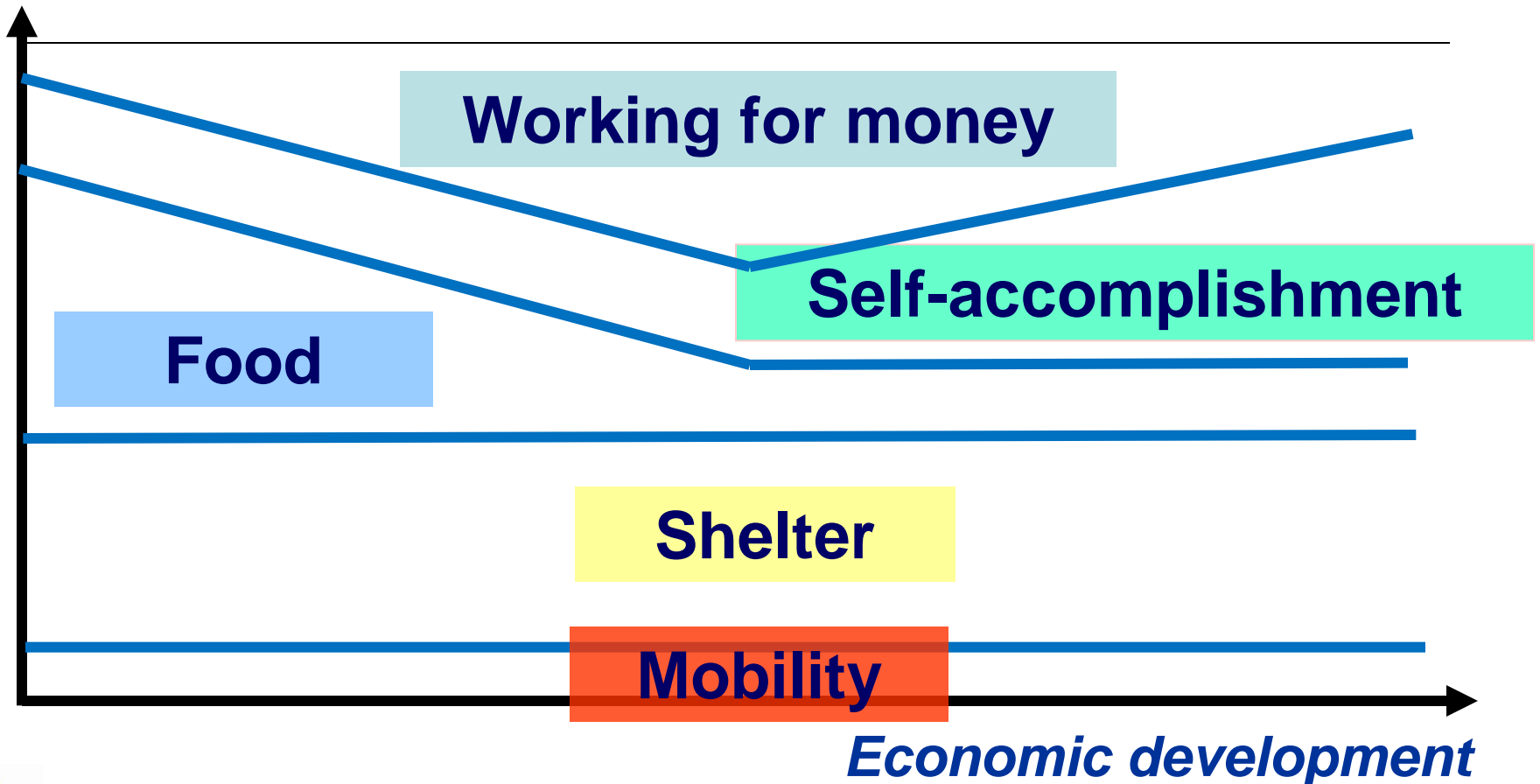
# Paradigms for the second half of the century

- ◆ Technology will surely be part of the solution
- ◆ But the post-carbon paradigm will also be structured by new patterns in:
  - material use, recycling, « circular economy »
  - urban and territory planning
  - behaviours and lifestyles
- ◆ In a context of:
  - catch-up of the western economies by emerging countries
  - and of massive urbanization



# The VLEEM approach of basic needs, changing time-budgets and associated energy services

*Hours/year*



# Towards « post-carbon cities »

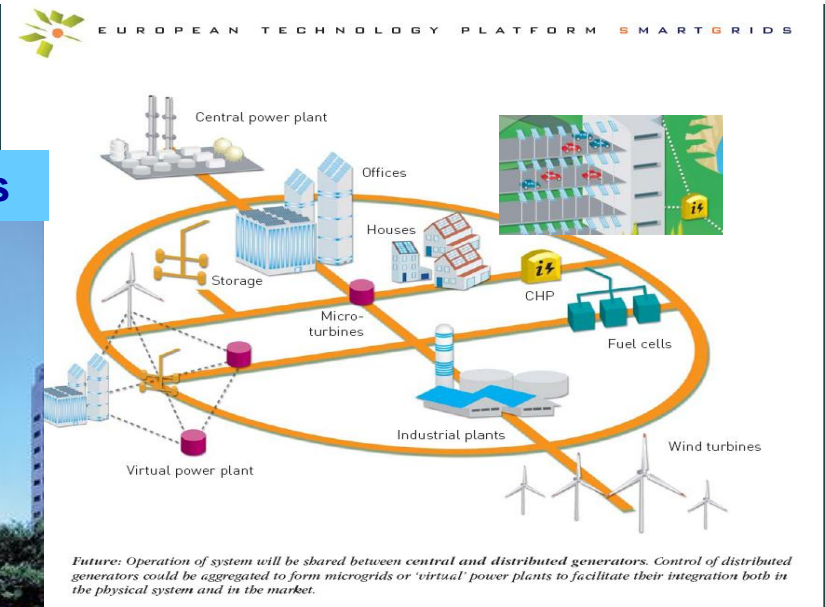
## Building-Transport Integration



## Nature & Agriculture in the Cities



## European Technology Platform Smartgrids



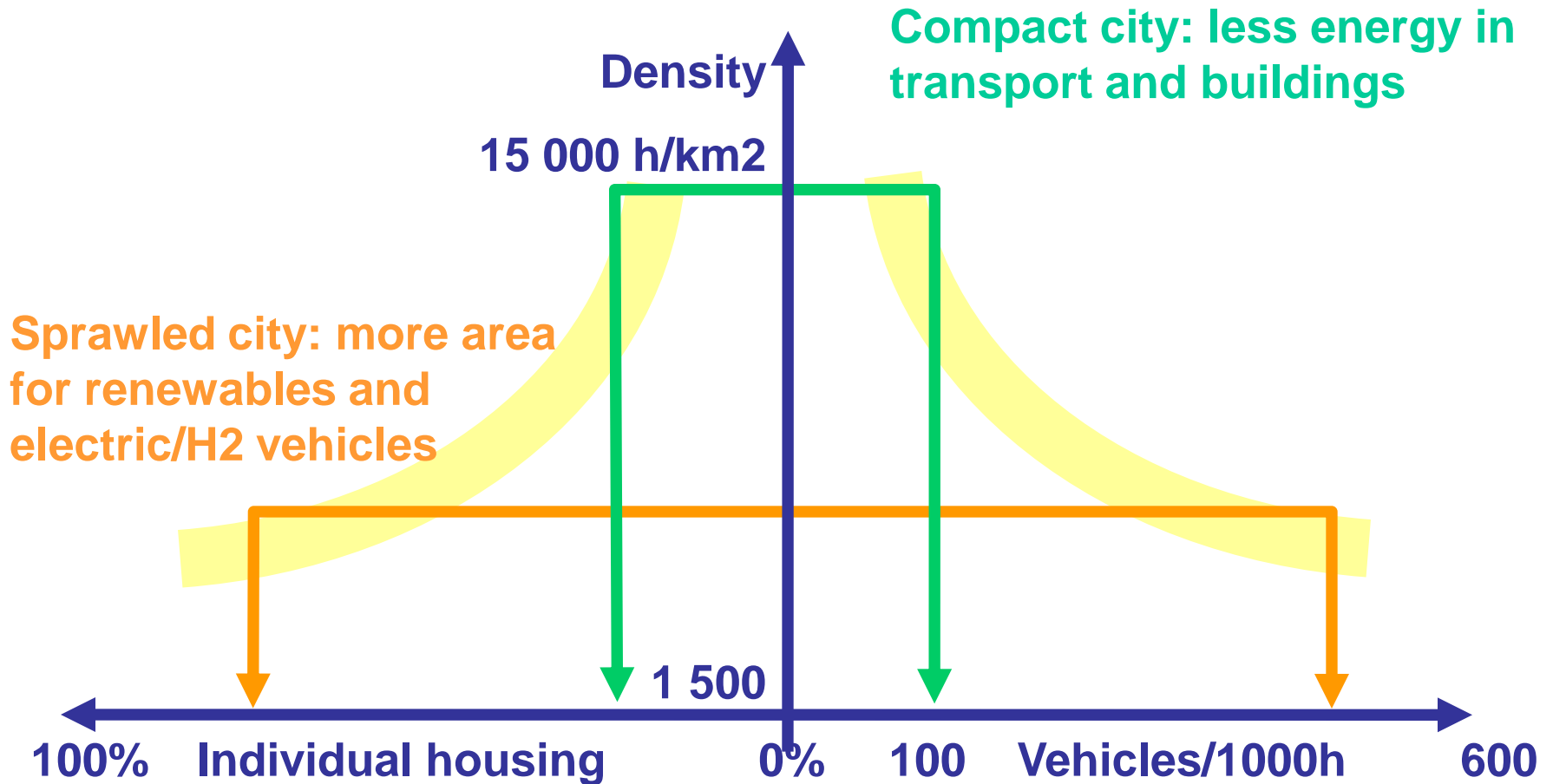
enger travel versus urban density

in global cities

Source: Newman and Kenworthy, 1989



# A complement to C. Sessa's view in PACT



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# Two challenges, a limited set of solutions

- ◆ The climate change challenge has to be addressed before 2050, while its full consequences will be felt only after 2050... however working for 2100 is already working for the new-borns of today
- ◆ If emission reduction policies, industrial ecology and urban policies are insufficient now, then the second half of the century will be dominated by scarcities, conflicts and climatic damages to social and natural systems



# Two challenges, a limited set of solutions

- ◆ In the implementation of a sustainable energy system beyond 2050, no option can be left aside
- ◆ The development of every energy paradigm – efficiency, renewable, nuclear, fossil – will crucially depend on two counter-balancing effects:
  - economies of scale, learning by doing and by searching that will reduce the cost of each technological option
  - decreasing returns, exhaustion of natural resource or physical potentials
- ◆ In that situation there is no “silver bullet”



# Two challenges, a limited set of solutions

- ◆ **Energy sobriety / energy efficiency.** Many model simulations show that it is a major option in post-carbon paradigms:
  - large potentials exist at very low cost
  - However, costs increase as standards are strengthened
- ◆ **Intermittent renewables:**
  - shares up to 30% of intermittent renewable can easily be managed in electricity grids through backup capacities
  - higher shares imply complex combinations of backup, storage (pumped or chemical), DC Supergrids, local Smartgrids...



# Two challenges, a limited set of solutions

## ◆ Biomass for heat, electricity, liquid fuels:

- the potentials are significant particularly if foreign sources are considered (Latin America ?)
- however sustainability conditions and competition with food production are to be carefully considered

## ◆ Nuclear energy:

- the potential for nuclear energy remains significant in the long term, specially if GEN4 (and fusion) reactors prove to be operational
- safety, dissemination and social acceptability issues remain the key limiting factors



# Two challenges, a limited set of solutions

## ◆ Carbon Capture and Sequestration

- economic feasibility may be reached for a carbon price of 80-100€/tCO<sub>2</sub>, but larges scale industrial deployment cannot be expected before 2030
- “onshore” carbon storage may be strongly limited by the NUMBY syndrome

## ◆ Other options:

- REDD+
- Climate engineering
- ...



# Two challenges, a limited set of solutions

- ◆ As seen from today, no single energy paradigm is bound to dominate the XXI<sup>st</sup> century
- ◆ From the basket of solutions to be implemented in 2050, it might thus be unwise to pick a winner today, while betting on its capacity to solve the problem beyond 2050
- ◆ This has clear implications for energy and climate R&D policies, which, in spite of the current financial constraints, should allow to keep the different options open

