Modèles et scénarios de décarbonation:

quels enseignements pour les politiques technologiques ?

P. Criqui

EDDEN, CNRS-UGA

Trois paradigmes et quatre échelles

MODELS SCENARIOS TRANSITION STUDIES	IAMs - Integrated Assessment Models	NATIONAL DECARBONIZATION SCENARIOS	SECTORAL & URBAN TRANSITION STUDIES
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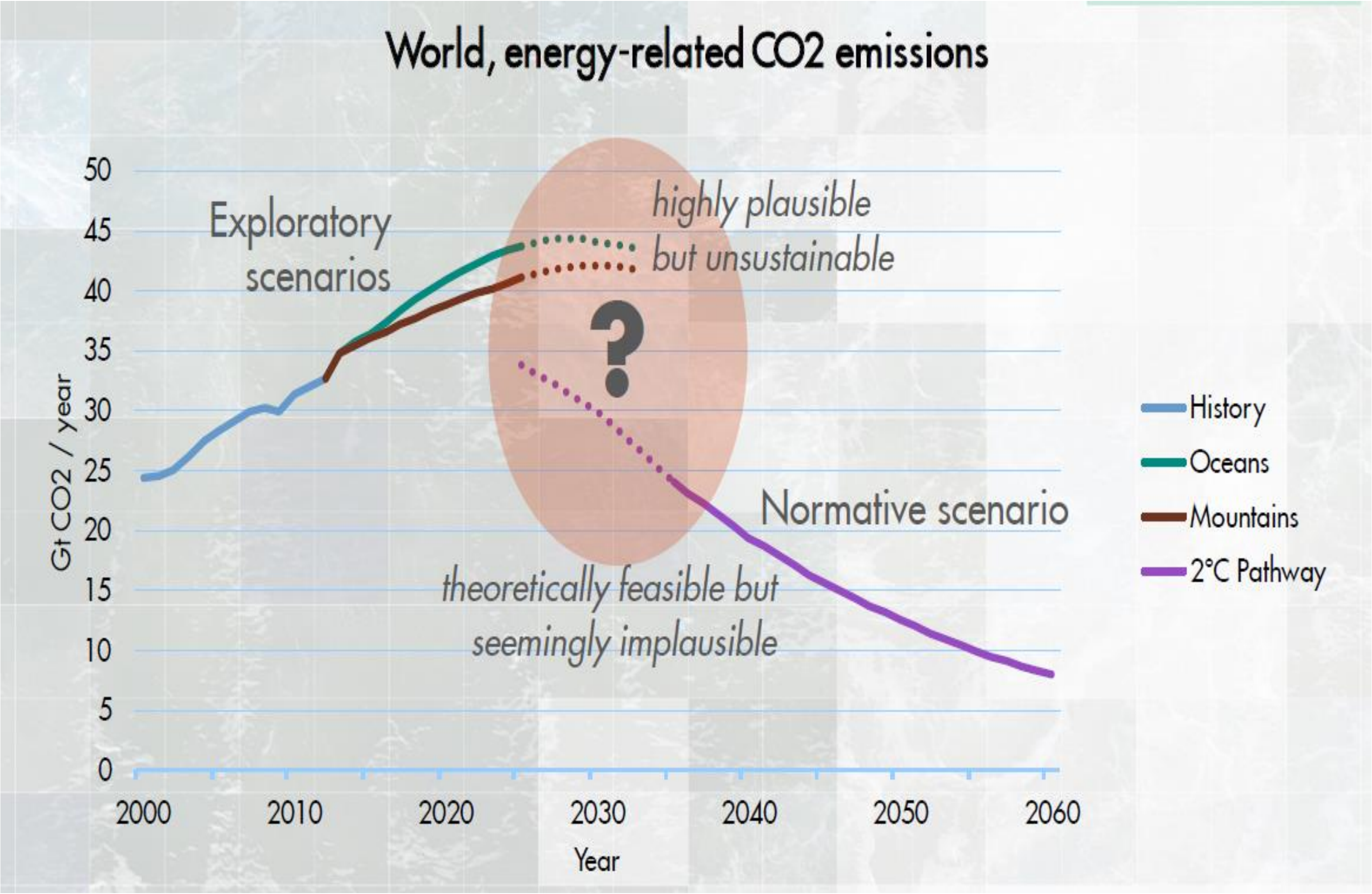
Les scénarios comme outils de la transition:
« la politique est l'art de rendre possible ce qui est souhaitable »



Source SHELL: Mountains and Oceans scenarios

The AMPERE FP7 Consortium :

AMPERE

Project Coordinator:
Potsdam Institute for Climate Impact Research (PIK)

International Institute for Applied Systems Analysis (IIASA)

Utrecht University (UU)

Fondazione Eni Enrico Mattei (FEEM)

Institute of Communication and Computer Systems (ICCS)

Centre for European Policy Studies (CEPS)

Centre International de Recherche sur l'Environnement et le Développement (CIRED)

Paul Scherrer Institut (PSI)

Centre national de la recherche scientifique (CNRS)

Enerdata

EU-JRC-Institute for Prospective Technology Studies (IPTS)

University of Stuttgart

Vienna Technical University, Energy Economics Group (EEG)

CPB Netherlands Bureau for Economic Policy Analysis

Université Paris I Pantheon-Sorbonne (ERASME)

MetOffice Hadley Centre

Climate Analytics

National Institute for Environmental Studies (NIES)

Research Institute of Innovative Technology for the Earth (RITE)

NDRC Energy Research Institute (ERI)

Indian Institute of Management (IIM)

External partner:
Pacific Northwest National Laboratory's Joint Global Change Research Institute (JGCRI)

Tools: IAMs in the FP7 AMPERE project

AMPERE is a unique European modeling platform

- Bringing together European groups with 10 global and 6 EU27 energy-economy / integrated assessment models
- Plus 5 groups from China (ERI), India (IIM), Japan (NIES, RITE), USA (PNNL)
- Plus 2 climate modeling groups (ClimateAnalytics, Hadley Centre)

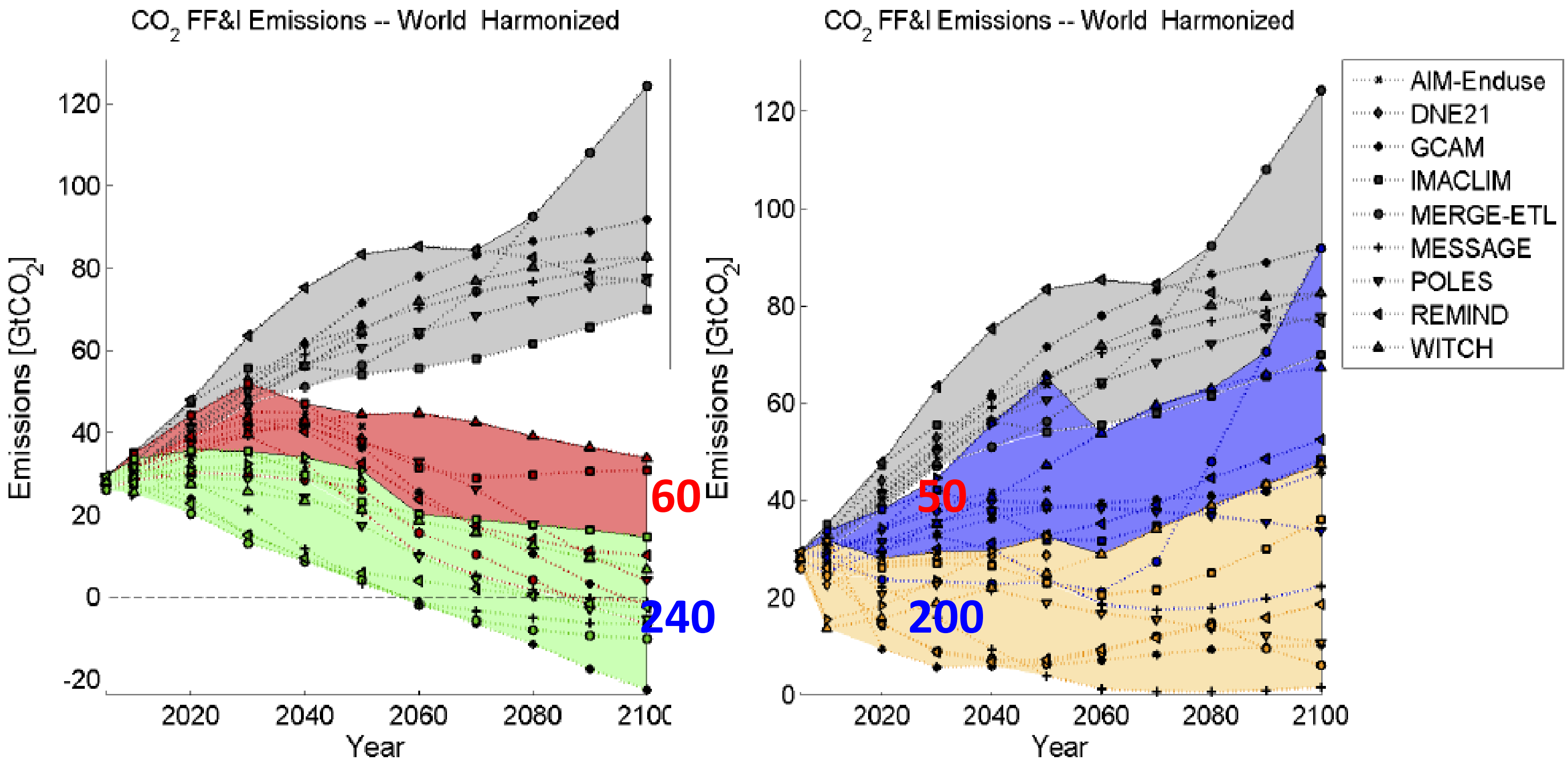
	Inter-temporal GE model	CGE	Partial equilibrium energy system model		Other (Bottom-up / econometric models)
Global	REMIND	IMACLIM	IMAGE / TIMER	DNE21+	
Global	WITCH	WorldScan (EU detail)	TIAM-IER	IPAC	
Global	MESSAGE-MACRO	GEM-E3	POLES	GCAM	
Global	MERGE-ETL	AIM			
EU27		GEM-E3	PRIMES, Green-X TIMES-PanEU		GAINS, NEMESIS
India			MARKAL India		

Source: Elmar Kriegler PIK, AMPERE Venice meeting, 23-25 May 2012

AMPERE

FP7 AMPERE: diagnostics and validation

CO2 Fossil Fuel and Industry Emissions



$12.5, $50 increasing tax (4%/yr)

$50, $200 constant tax

AMPERE

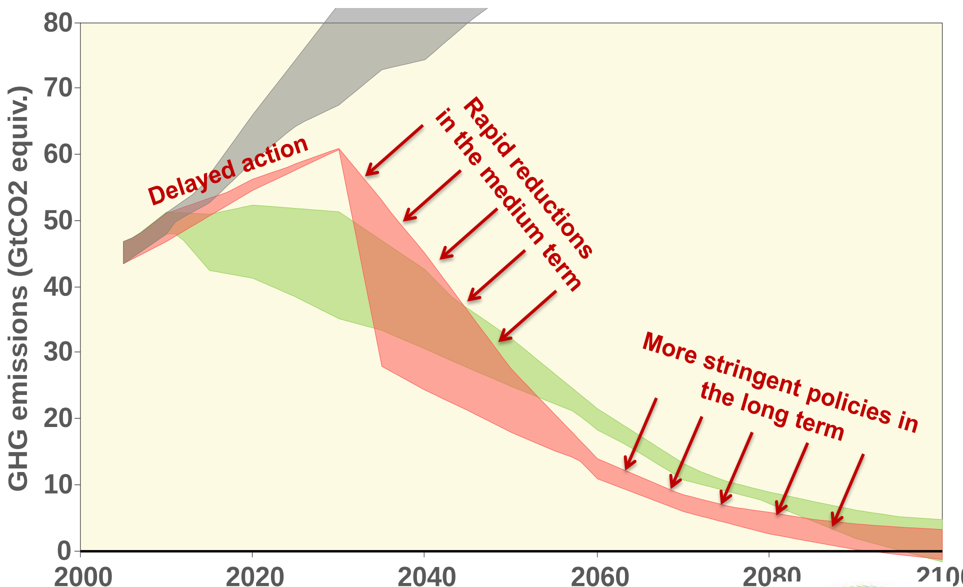
Source: Elmar Kriegler PIK, AMPERE Venice meeting, 23-25 May 2012

Climate goals and delay:

Delayed action results in the need for unprecedented mitigation in the following decades

- Near-term climate action by 2030 will be critical:
  - Continuation along current pledges exhausts ~70% of the emissions budget by 2030
  - The lack of near-term mitigation needs to be compensated by massive emissions reductions later in time
- The findings suggest global GHG emissions targets by 2030 of less than 50 GtCO2 globally with a 40% reduction for Europe

Implications of delayed action for reaching 2°C



AMPERE

An integrated energy, macroeconomic and industrial strategy (Pantelis Capros, AMPERE 2014)

AMPERE
Assessment of Climate Change Mitigation Pathways

4.1 The European Union's decarbonisation strategy requires strong 2030 targets

4.2 Carbon-free electricity, energy efficiency and transport electrification are critical for decarbonisation of the EU energy system

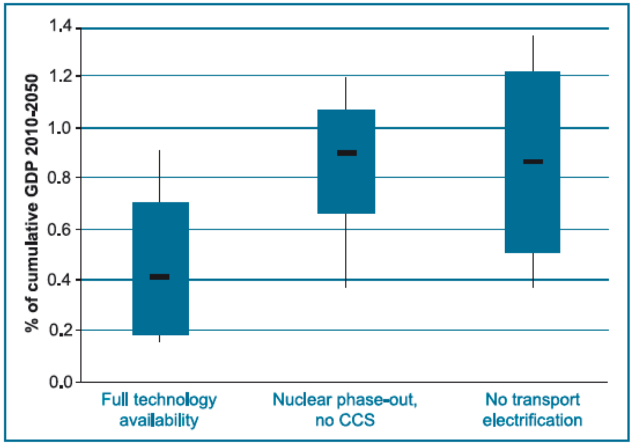
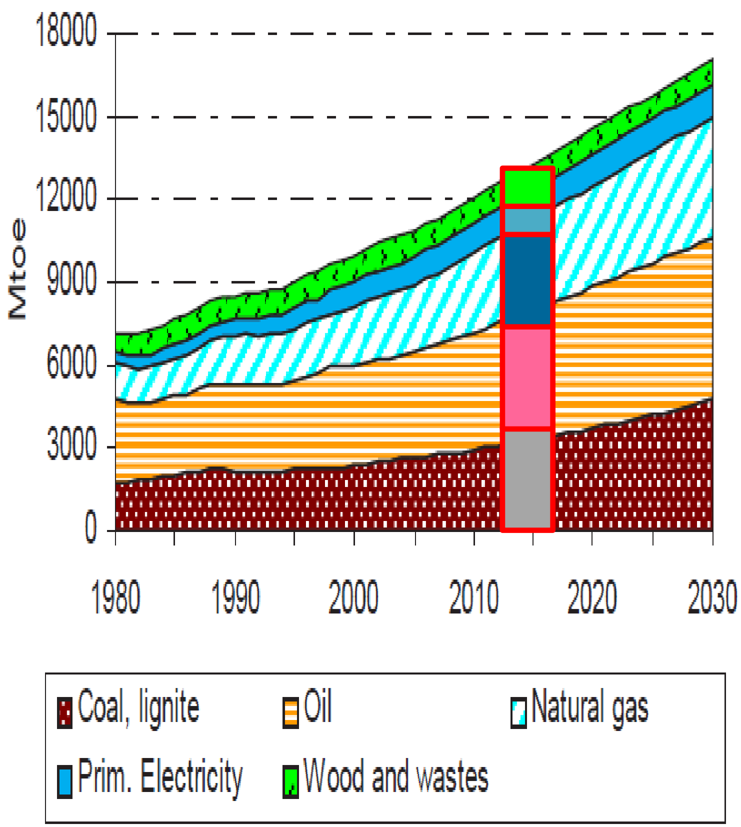


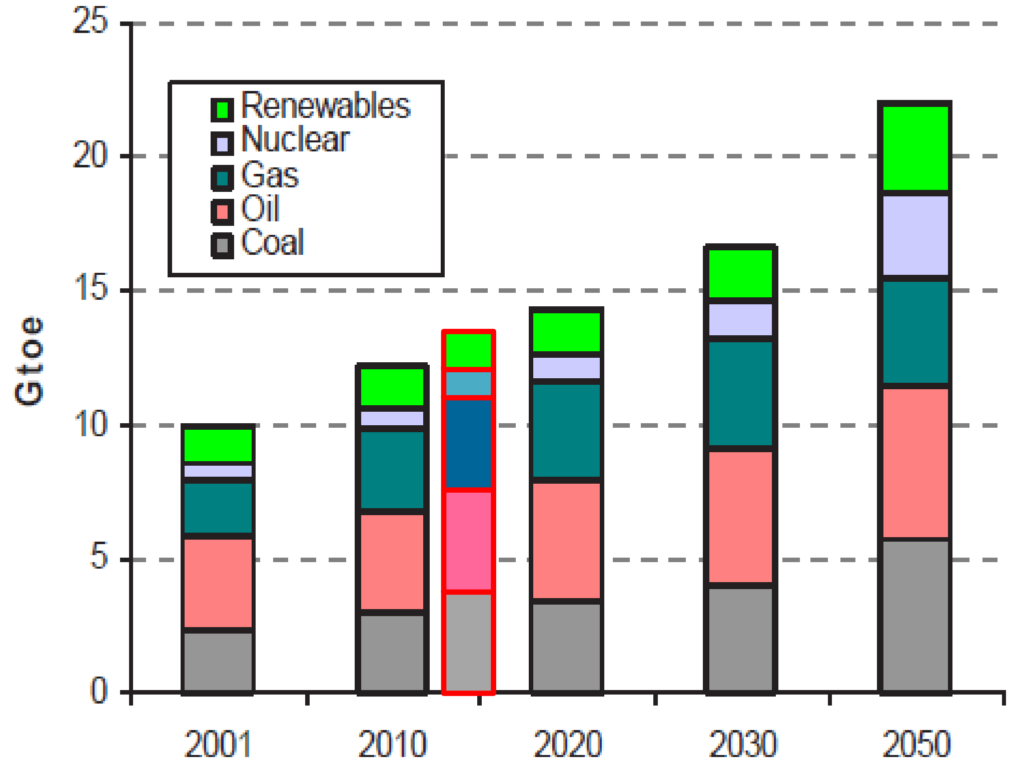
Figure 11: Decarbonisation costs under technological limitations for the EU relative to the reference in 2010-2050. Ranges and distribution of model results are shown by the boxplots, with black lines indicating the median. No discount rate is assumed.

4.3 Climate policies create opportunities for some European sectors and challenges for others

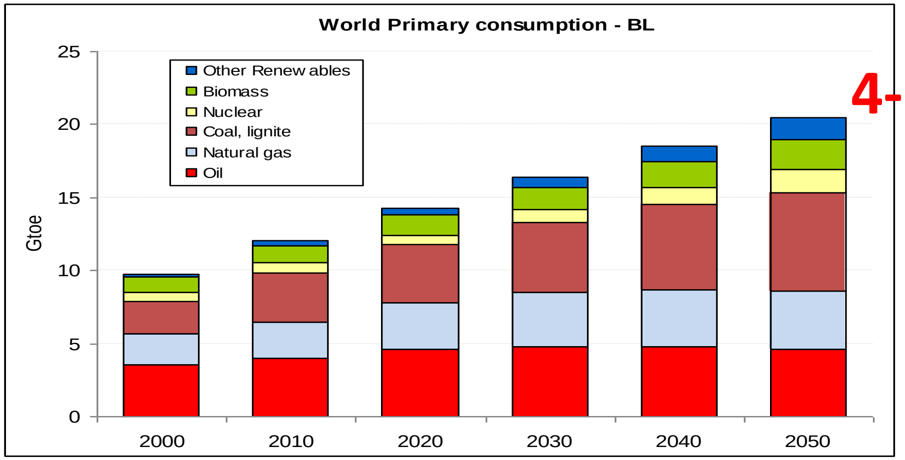
4.4 If other world regions start decarbonising later, Europe would gain a technological first mover advantage

Modèle POLES:
résultats WETO 2003 et WETO-H2 2005 / BP 2014

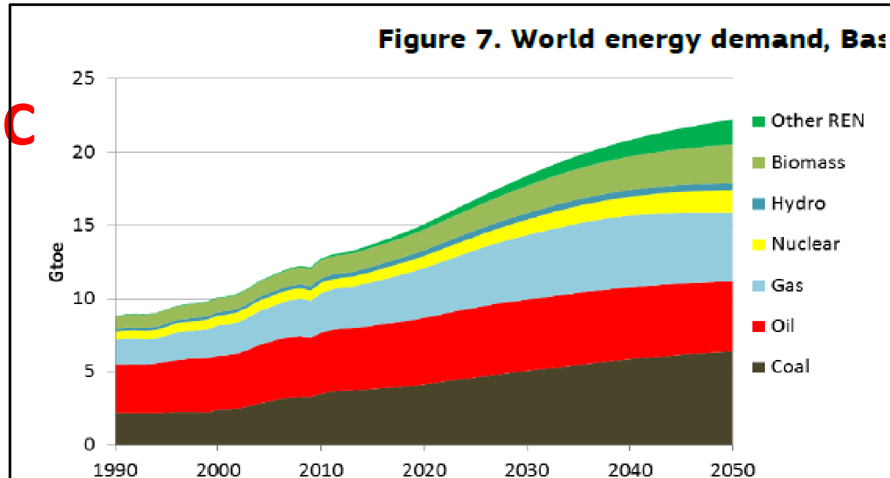




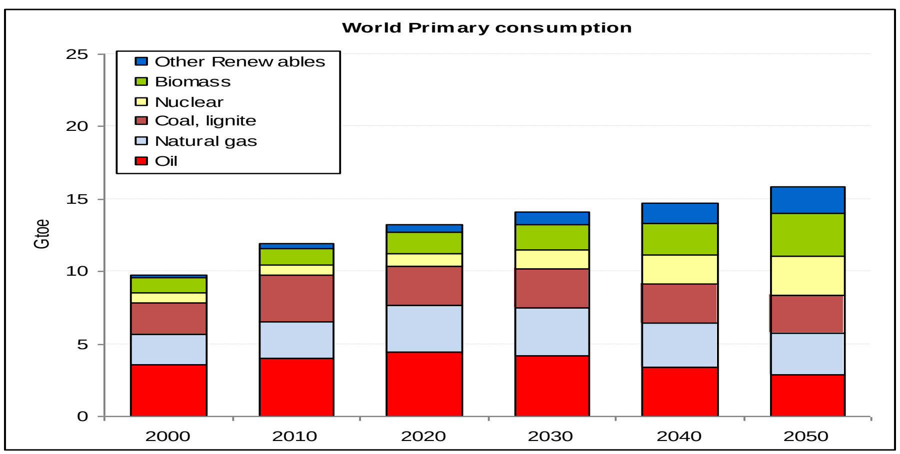
Modèle POLES: résultats SECURE 2010 et GECO 2015

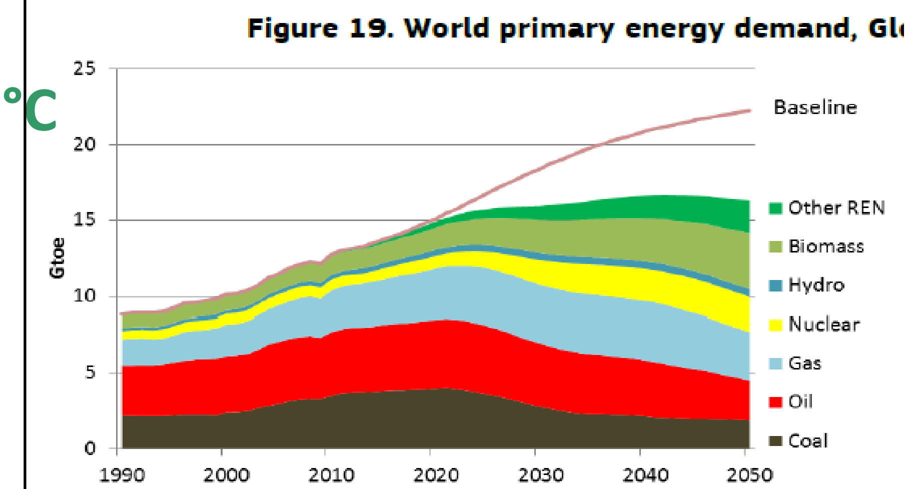


4-5°C



2°C

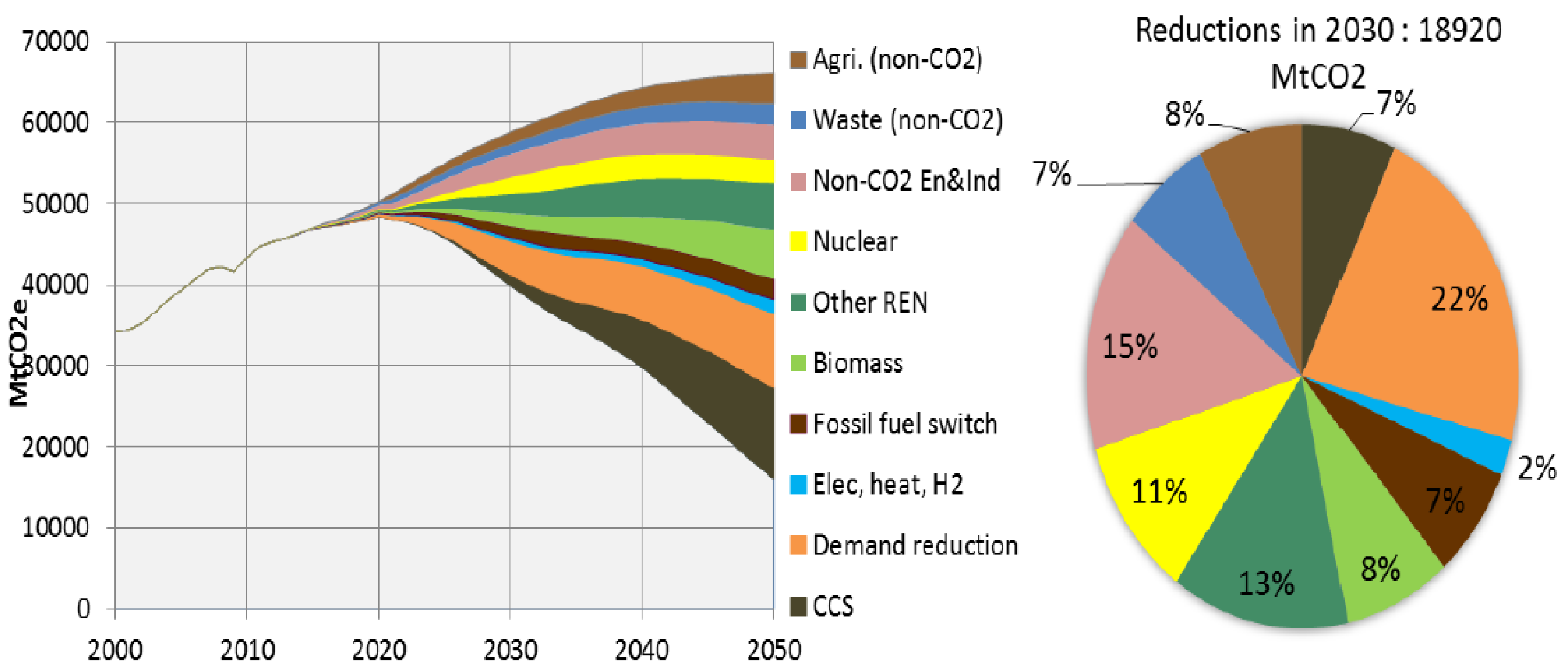




Source; LEPII-EDDEN, modèle POLES

Modèle POLES: une analyse des Decarbonization Wedges dans GECO 2015

Figure 28. Emission mitigation options: World (excl. LULUCF)



Source: JRC POLES model

Trois paradigmes et quatre échelles

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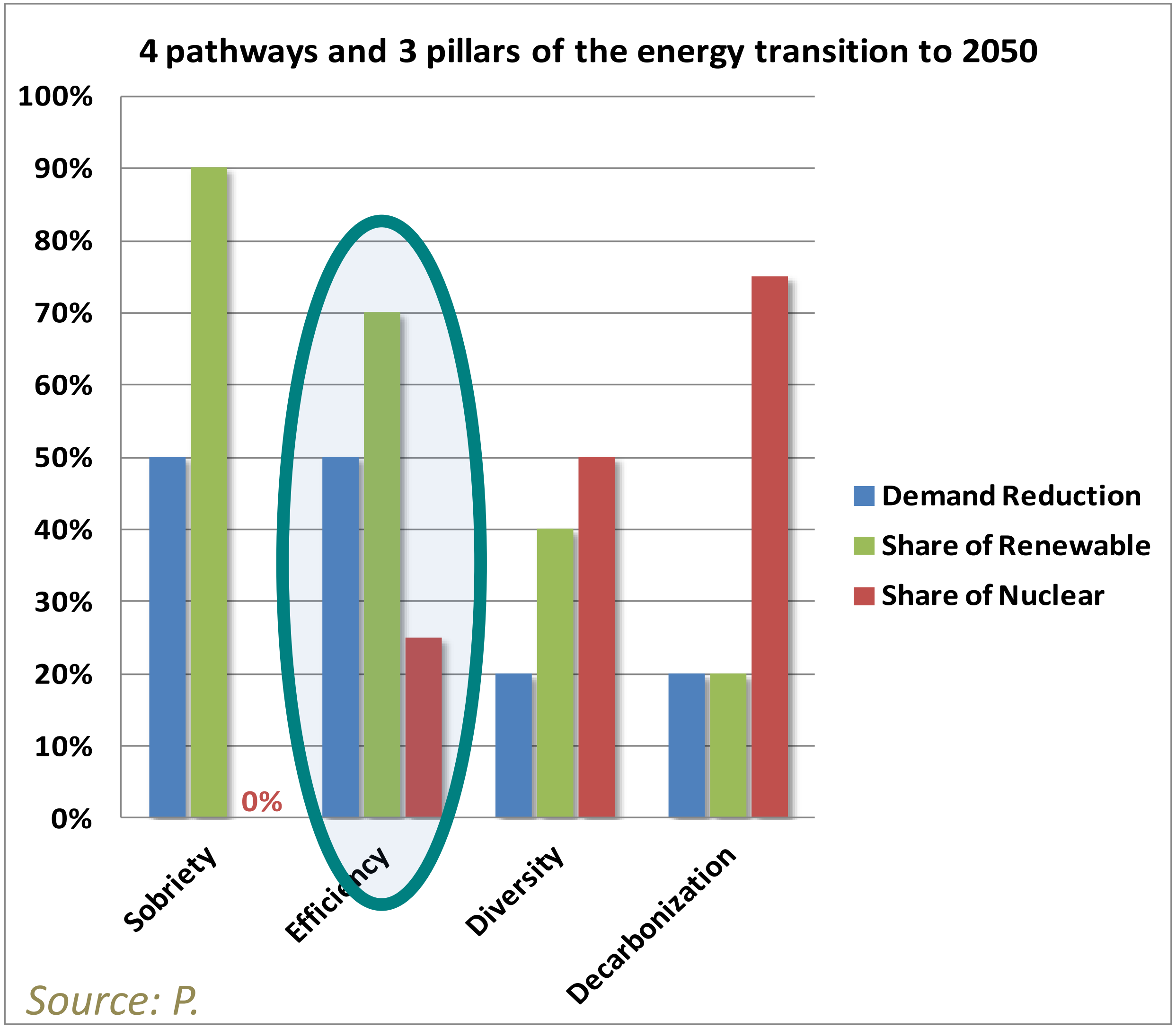
Conseil National du DNTE: 7 collèges de 16 membres

1. ONG Enviro.
2. Assoc. Consos.
3. Syndicats
4. Employeurs
5. Coll. Locales
6. Parlement
7. Administration

The "Law on Energy Transition for a Green Growth"

- All-GHGs emission reduction by 40% in 2030 (EU target) and 75% in 2050 (compared to 1990)
- Reduction in final energy consumption by 50% in 2050 compared to 2012 ;
- Reduction in fossil energy consumption by 30% in 2030/2012
- Share of renewable of 23% of total consumption in 2020 and 32% in 2030, of which: 38% of heat, 15% of transport fuels, 40% of electricity
- Share of nuclear energy down to 50% of electricity generation in 2025 (and a cap of 63 Gwe of installed capacity)
- Complementary quantitative targets for:
  - 500 000 thermal retrofitting per year by 2017
  - 7 millions loading docks for electric vehicles in 2030
  - 1 500 biodigesters between 2015 and 2017

Trois variables clé pour la transition et un scenario “first best” dans la loi TECV

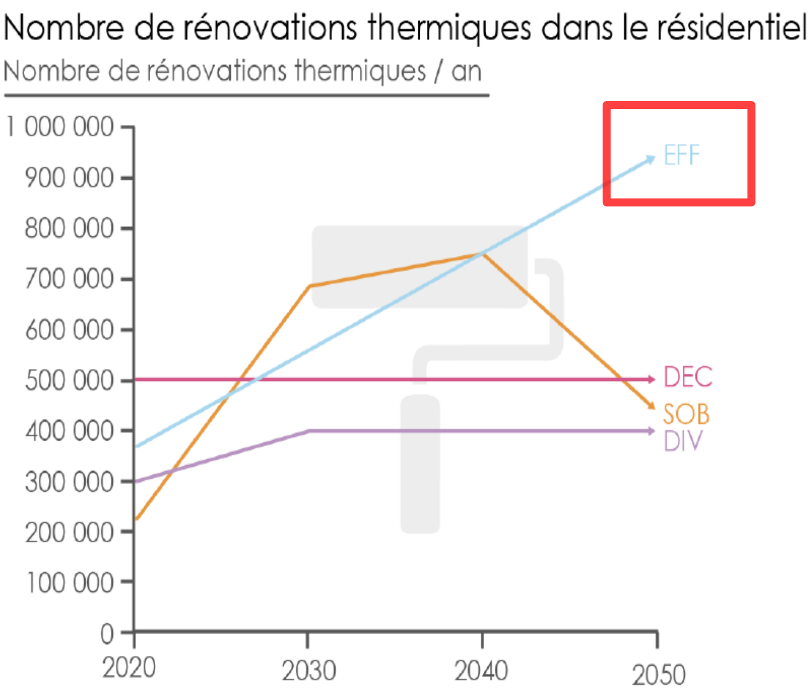


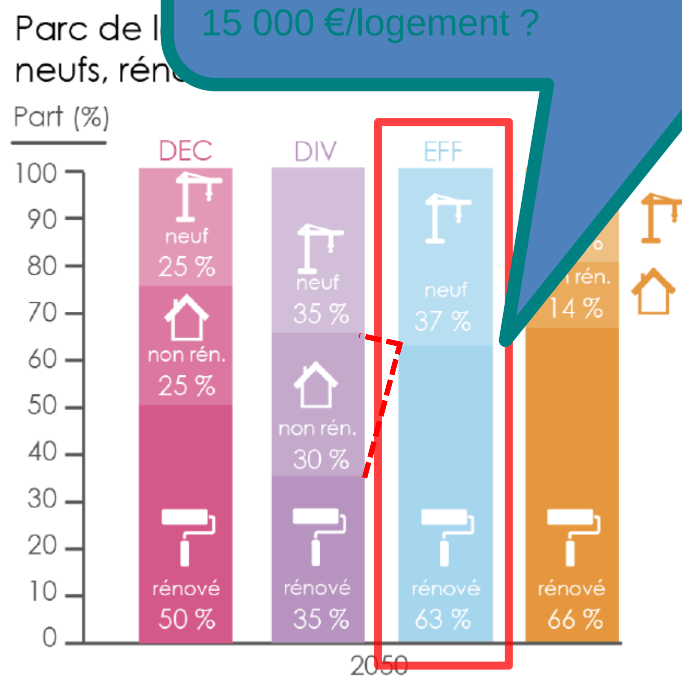
Source: P. Criqui

EFF: The role of building retrofit

- Building energy retrofit is a key dimension of energy demand reduction
- In **EFF** all existing buildings should be r… high level of energy performance

Défi 1: assurer 500 000 rénovation profondes par an pour une économie d'environ 1 000 €/an et un investissement minimum de 15 000 €/logement ?



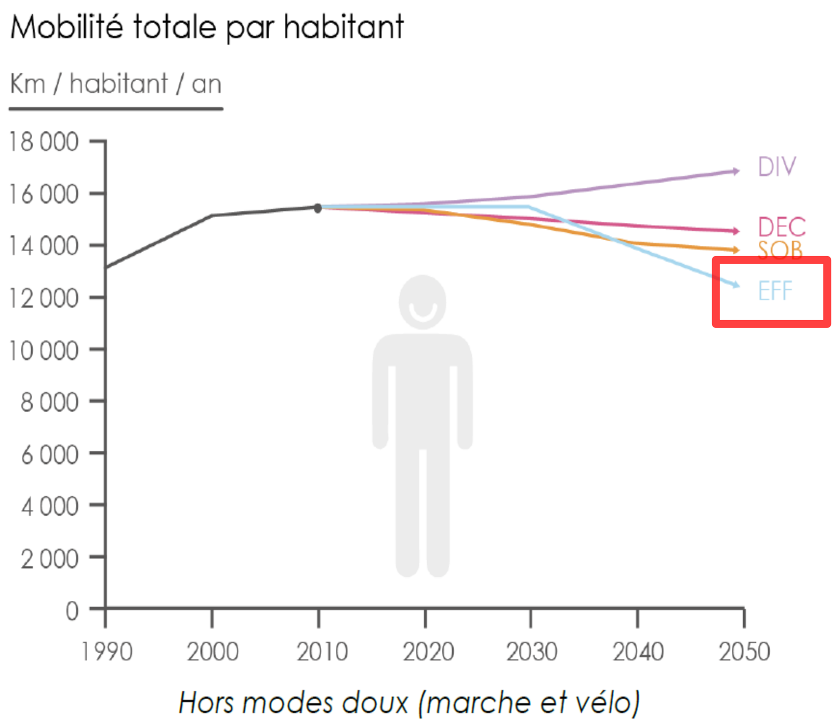


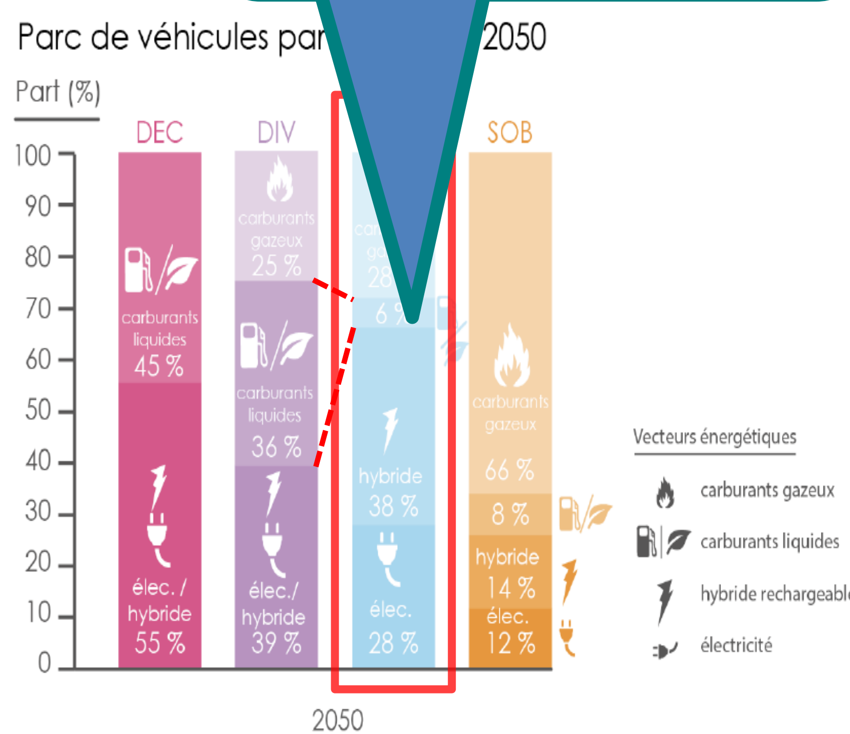
Source: Carbone 4

EFF: trend changes in transport

- **EFF** supposes a leveling-off and after 2030 a decrease in total personal mobility
- It also supposes that in 2050 EV or HEV vehicle stock (with 28% of gas vehicles)

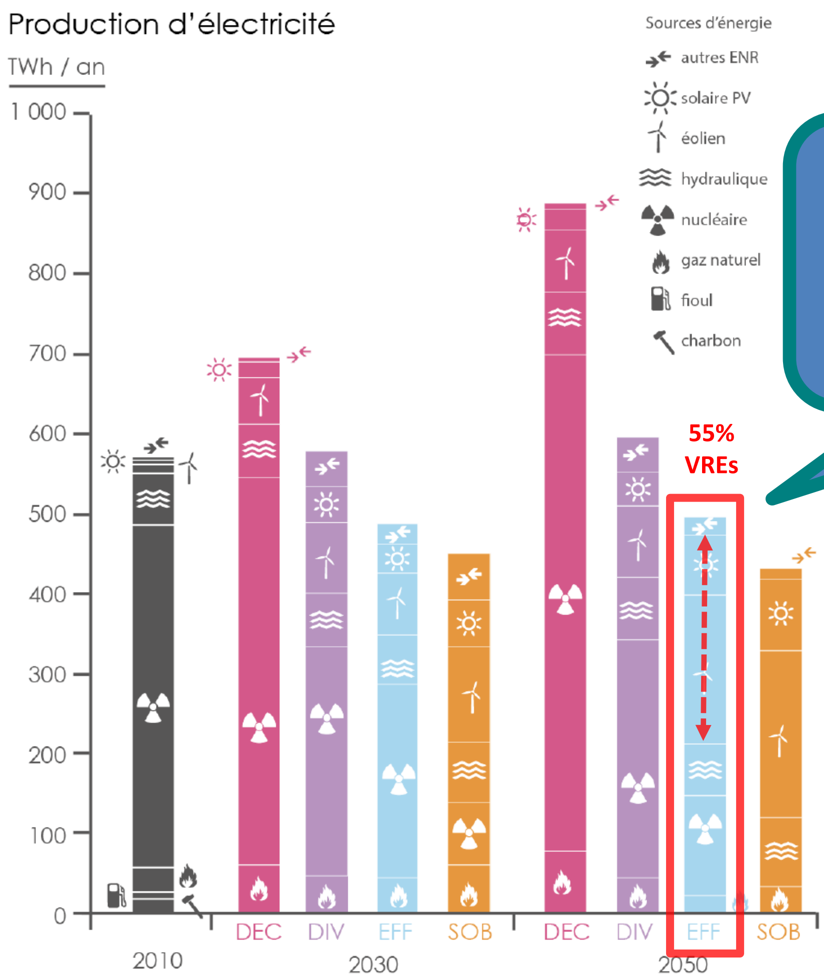
Défi 2: assurer l'électrification de 2/3 des véhicules (500 000 ventes/an) pour une économie d'environ 1 000 €/an et un surcout du véhicule de 8 000 € ?



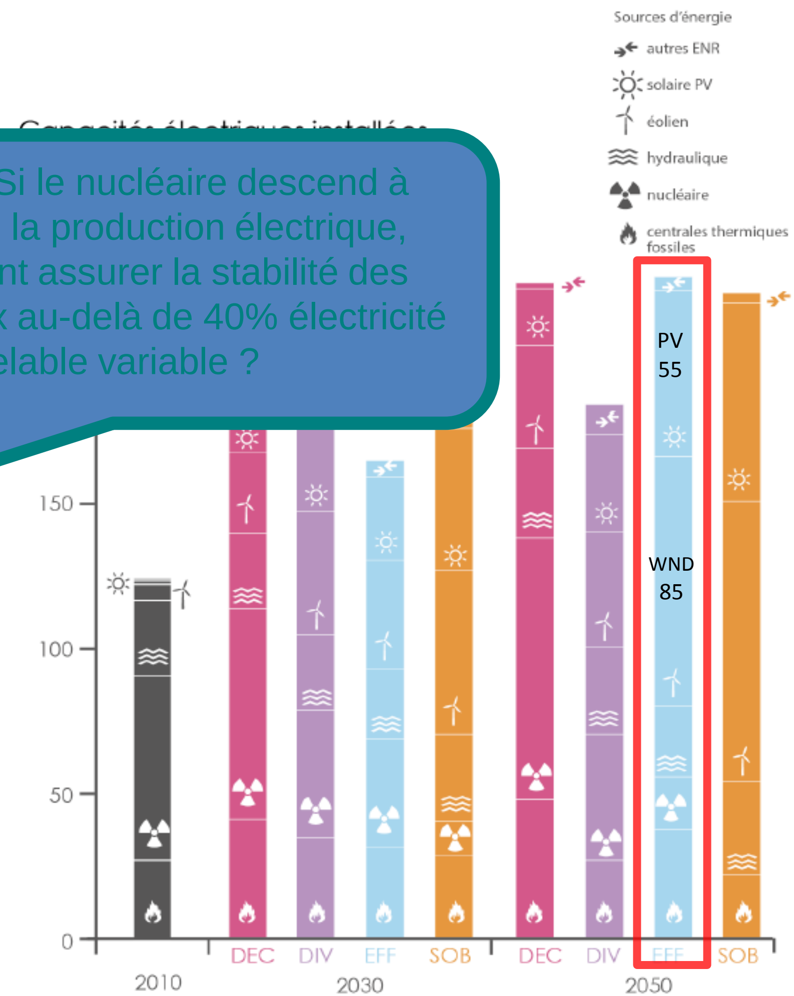


Source: Carbone 4

EFF: 70% RES with 55% of VREs in power generation

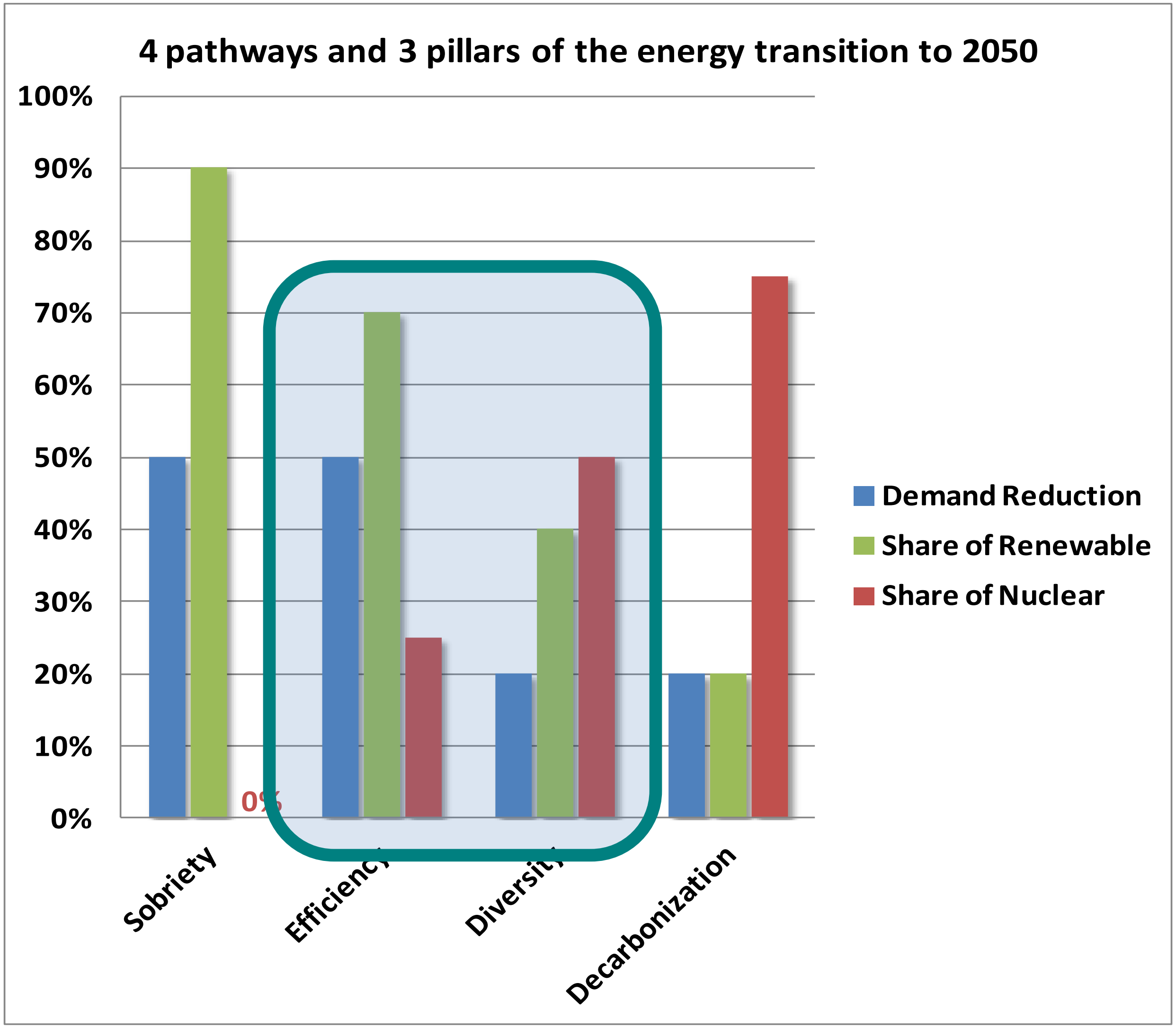


Défi 3: Si le nucléaire descend à 25% de la production électrique, comment assurer la stabilité des réseaux au-delà de 40% électricité renouvelable variable ?



Source: Carbone 4

“First best” and “second best” scenarios: towards a dynamic management of the energy transition



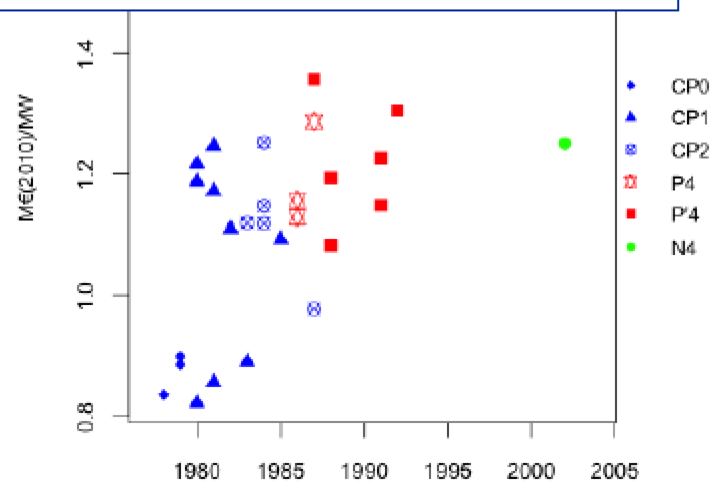
What costs for future nuc

According to econometric studies (Escobar and Leveque, 2012)

- The scale-up is the main driver of the increase in the costs. Building larger reactors took more time and they turn out to be more expensive
- The cost of labor is also one important driver of the construction costs, it grew faster than the price index used to homogenize the cost data
- There is no evidence of learning effects at the industry level. However we found positive learning effects at the palier and type level
- Safety concerns also took part in the cost escalation. The reactors with better performance in terms of safety indicators were also more expensive

Défi 4: Si la part du nucléaire est maintenue à 50% jusqu'en 2050, comment gérer l'alternative prolongement de la durée de vie / construction de nouvelles tranches ?
Défi 4bis: Quel design et quels couts pour la G3 ?

EPR 2025: 4 500 €/kWe ?



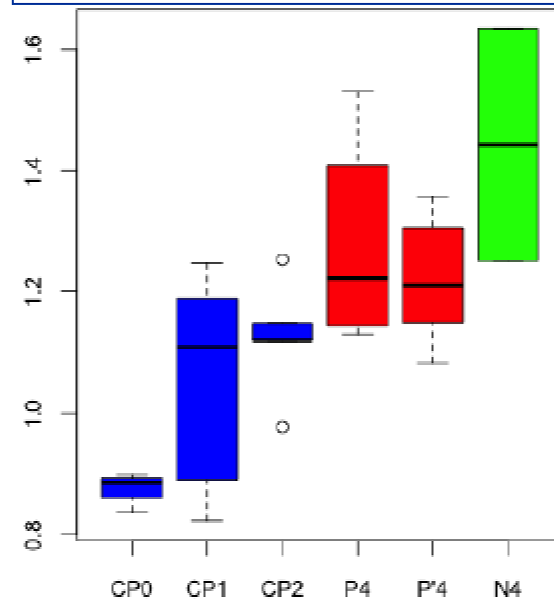


Figure 2: Cour de Comptes construction cost by Palier and Type

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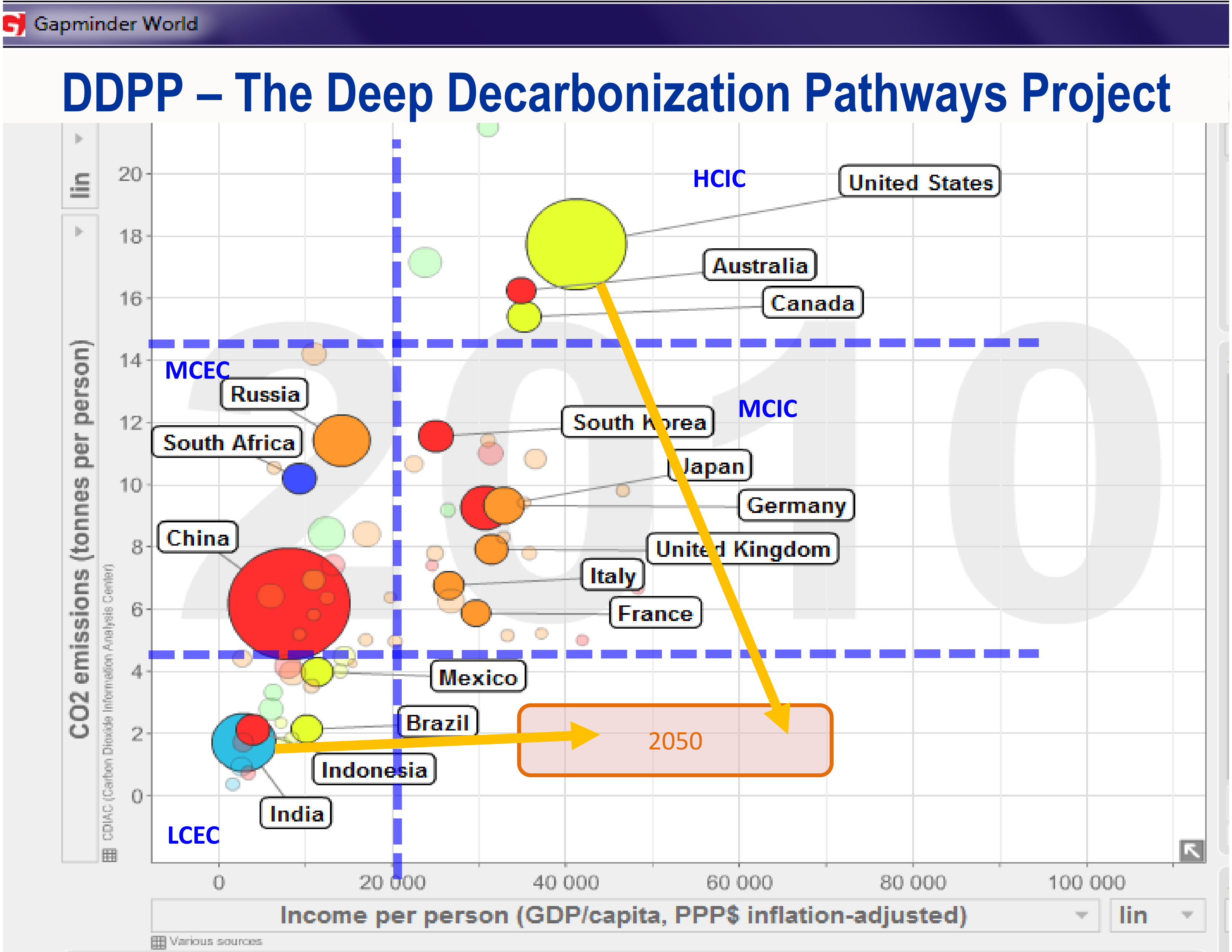
The DDPP - Deep Decarbonisation Pathway Project

(IDDRI-SDSN)

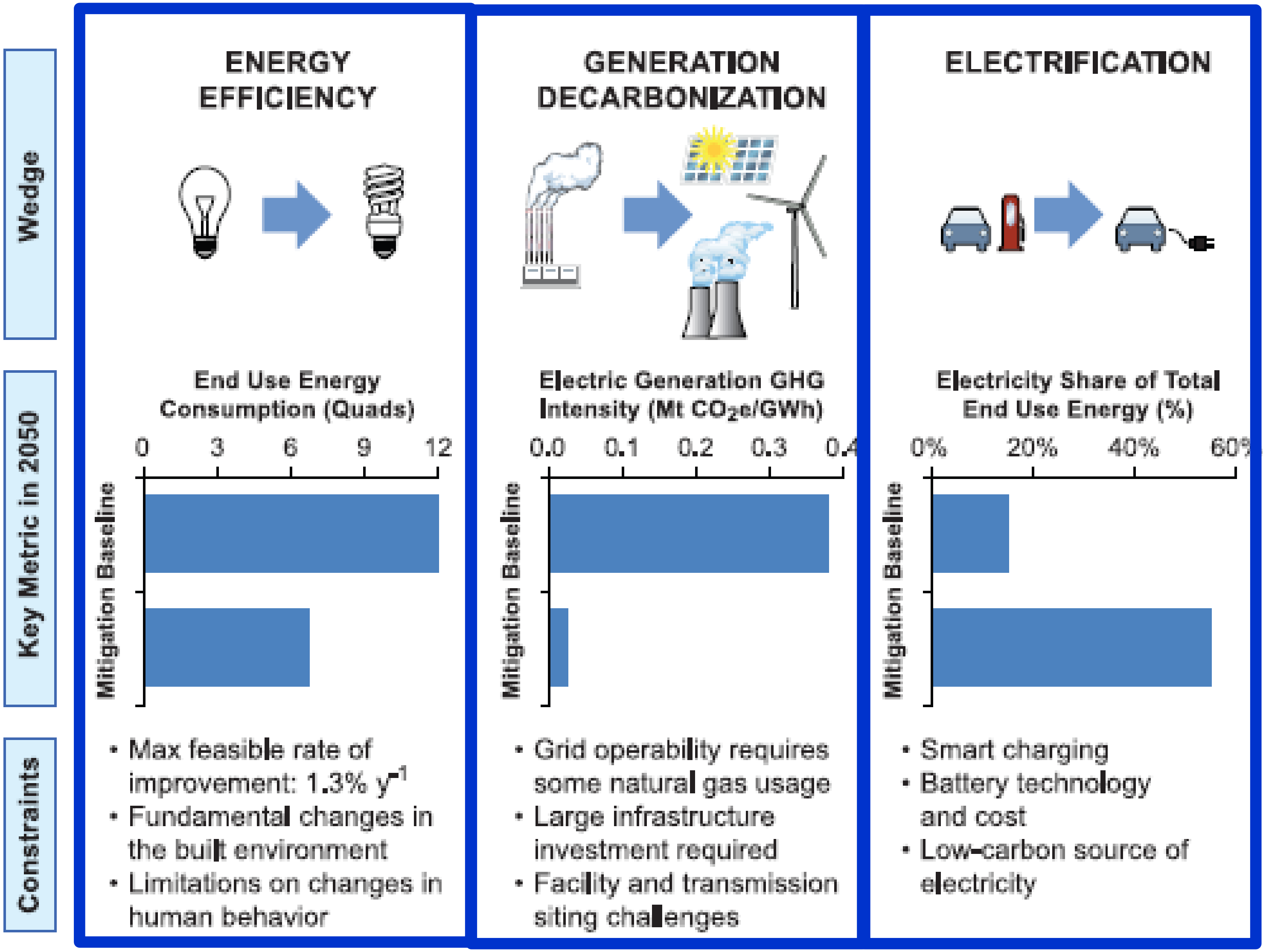
- *32 leading research institutions from 16 countries (Australia, Brazil, China, European Union, India, Indonesia, Japan, Mexico, Russia, South Africa, South Korea, the United States of America), covering more than 70% of global C02 emissions. The project aims to:*
  1. *Prepare transparent national deep decarbonization pathways to 2050 to help countries adopt and implement policies to achieve deep decarbonization.*
  2. *Support a positive outcome of the UNFCCC international climate negotiations by 2015 by helping national decision makers and the international community to understand what deep decarbonization implies for individual countries and regions.*
  3. *Review aggregate global emission reduction pathways prepared for AR5 by the WG III in light of the national decarbonization pathways.*
  4. *Build an on-going global network to facilitate learning and promote problem solving in the implementation phase of national of deep decarbonization strategies after 2015*

DDPP – The Deep Decarbonization Pathways Project



Les trois piliers de la décarbonisation

(Jim Williams, E3 San Francisco, Science 2012)



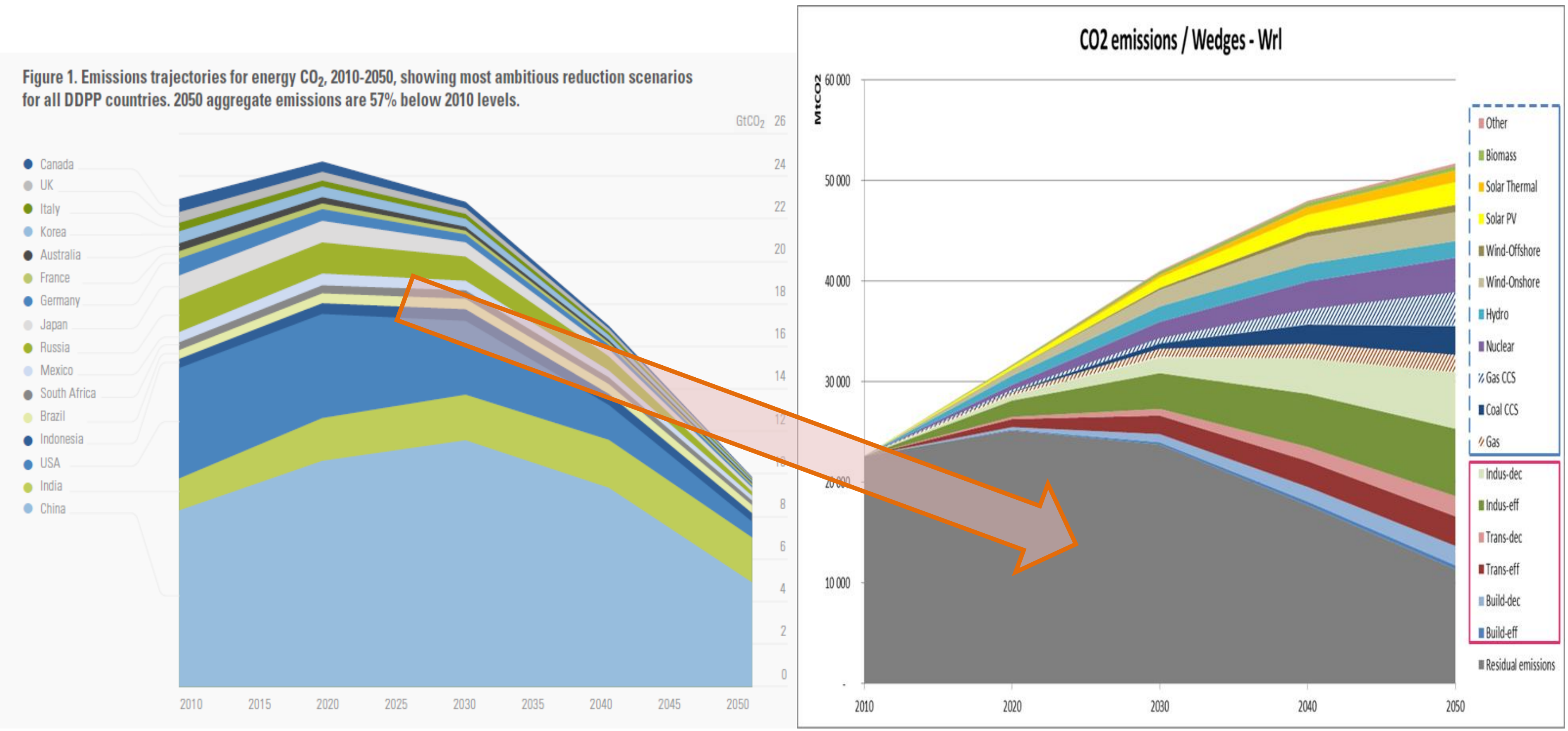
ANCRE is a national research alliance created in 2009

- Funding members: CEA, CNRS, CPU, IFPEN

Associated members : ANDRA, BRGM, CDEFI, IRSTEA, CIRAD, CSTB, IFREMER, INERIS, INRA, IFSTTAR, INRIA, IRD, IRSN, LNE, ONERA

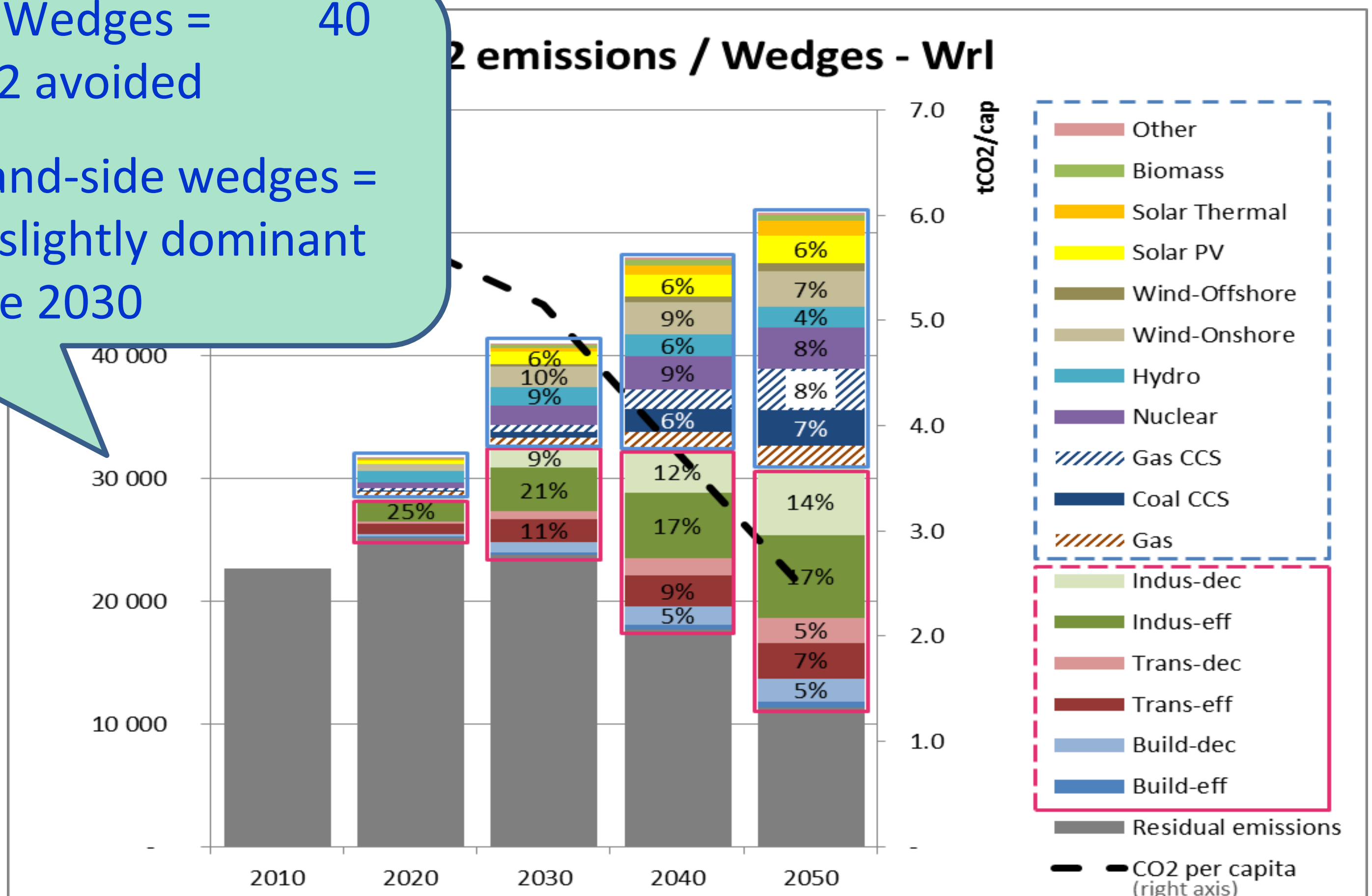
- GP1: Biomass & bioenergy
- GP2: Georesources for energy
- GP3: Nuclear
- GP4: Wind and marine energy
- GP5: Solar
- *GP6: Transport sector*
- *GP7: Building*
- *GP8: Industry*
- GP9: Socioeconomics & foresight
- GP10: Grids, systems, storage

Decarbonization Wedges from DDPP: From country wise to technology wise



Decarbonization Wedges from DDPP: the global outlook

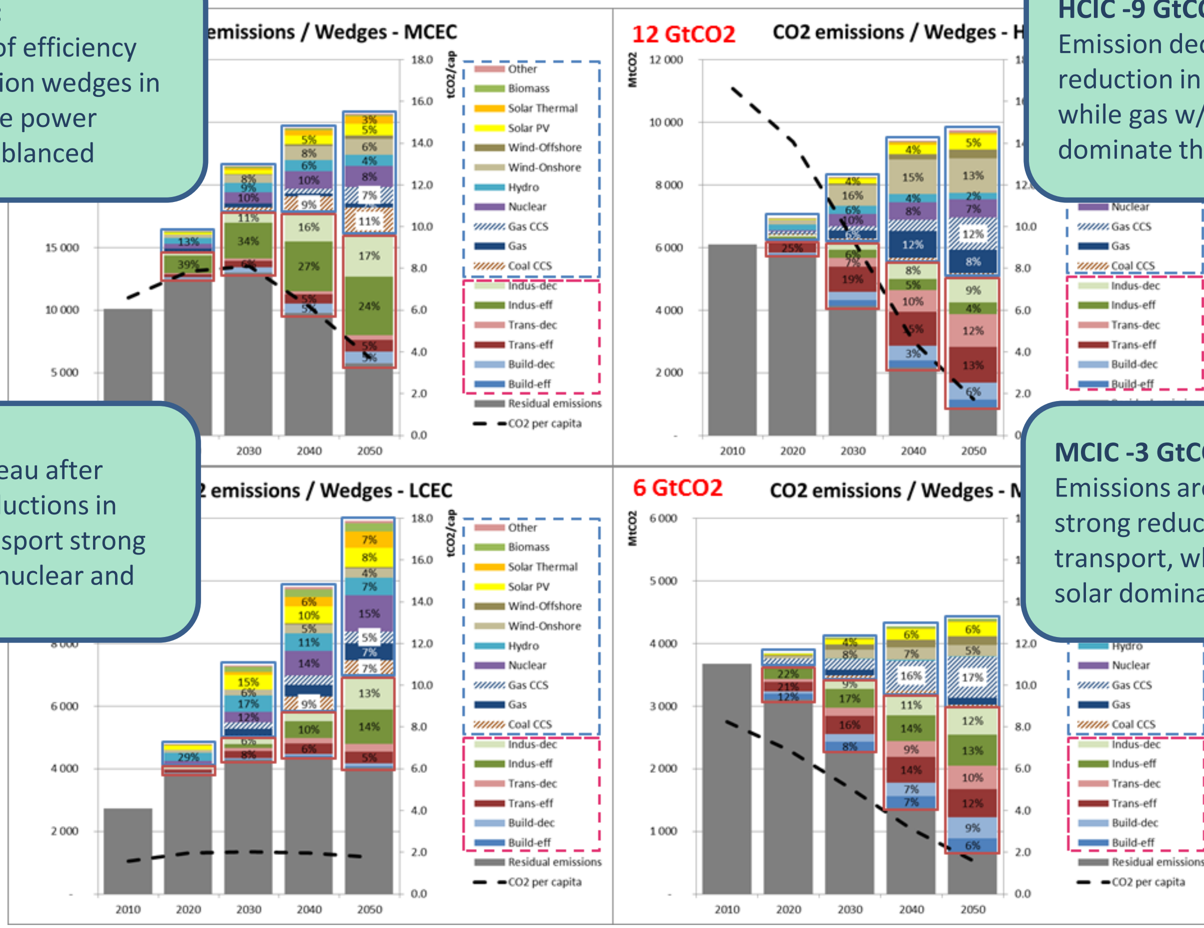
- Total Wedges = 40 GtCO2 avoided
- Demand-side wedges = 50%, slightly dominant before 2030



Decarbonization Wedges from DDPP: contrasted regional perspective

MCEC -20 GtCO2:
A dominant role of efficiency and decarbonization wedges in industry, while the power wedges are fairly blanced

HCIC -9 GtCO2:
Emission decrease rapidly after 2030, reduction in transport are significant while gas w/wo CCS and wind dominate the power sector

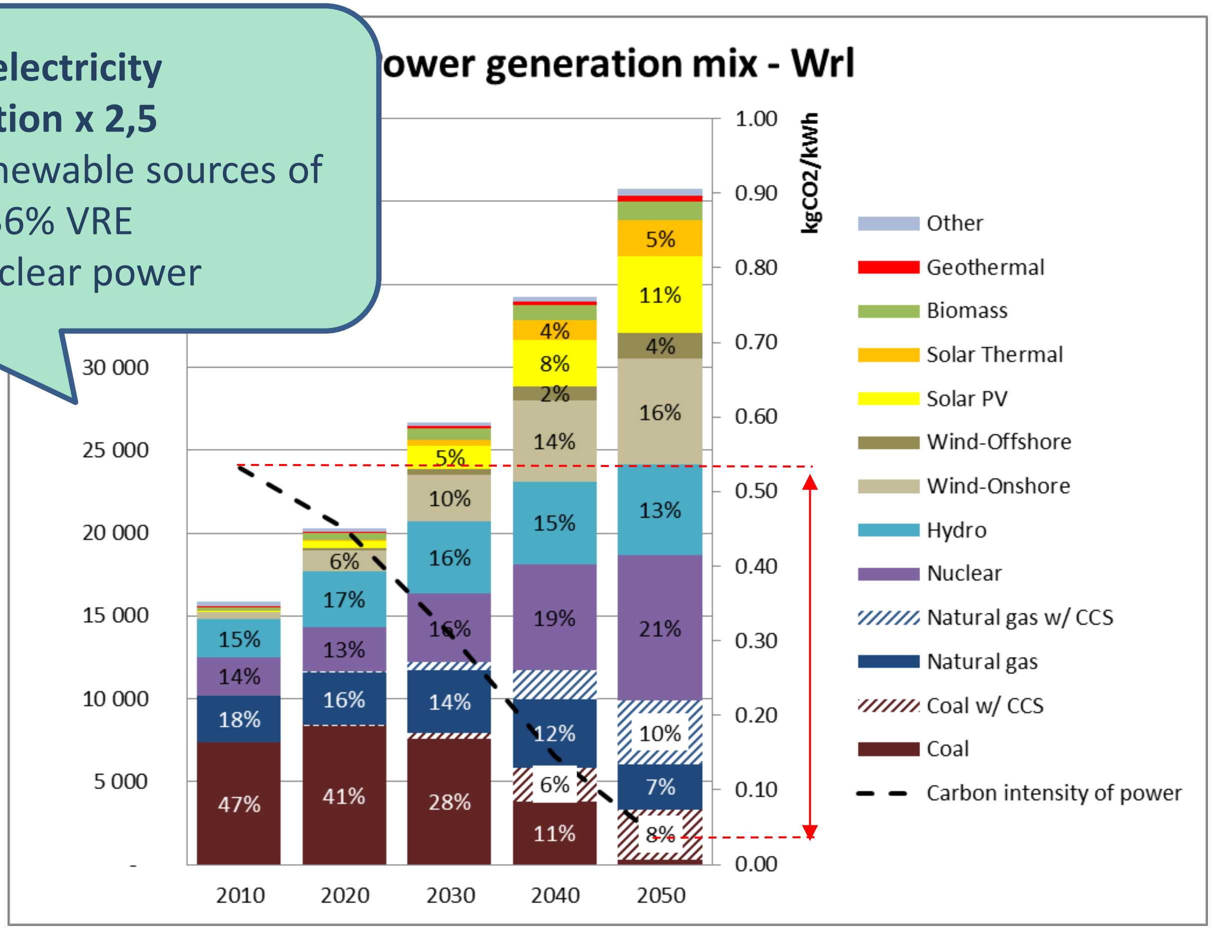


LCEC -8 GtCO2:
An emission plateau after 2020, limited reductions in building and transport strong contributions of nuclear and solar power

MCIC -3 GtCO2:
Emissions are reduced by 80%, strong reductions in buildings and transport, while gas+CCS, wind and solar dominate the power sector

Decarbonization Wedges from DDPP: a significant increase in electricity

World electricity production x 2,5
55% renewable sources of which 36% VRE
21% nuclear power



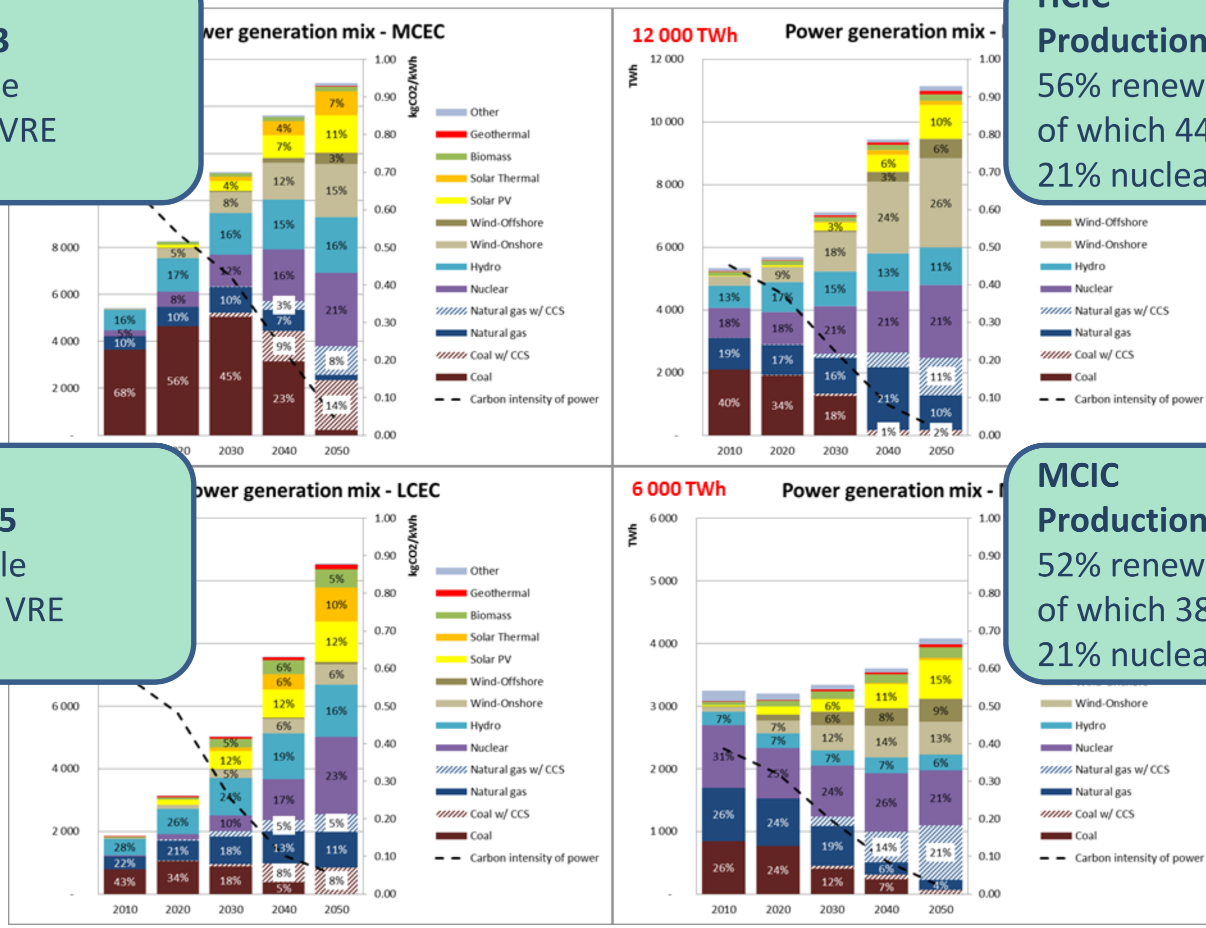
Decarbonization Wedges from DDPP: different electricity growth, similar power mix

MCEC
Production x 3
54% renewable
of which 36% VRE
21% nuclear

HCIC
Production x 2
56% renewable
of which 44% VRE
21% nuclear

LCEC
Production x 5
52% renewable
of which 30% VRE
23% nuclear

MCIC
Production x 1,25
52% renewable
of which 38% VRE
21% nuclear



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La dimension micro-économique: le projet AETIC

- L'économie d'un plan climat local doit utiliser des critères de coût-efficacité pour identifier les options à privilégier:

Bâtiments

- Rénovation patrimoine municip.
- Logements sociaux
- Programmes OPATB
- Opérations exemplaires TBE
- Eclairage public
- Maîtrise demande électricité
- …/…

Transports

- Planification urbaine
- PDU / PDE
- Transports collectifs
- Véhicules municipaux
- Modes doux
- Véhicules électriques
- …/…

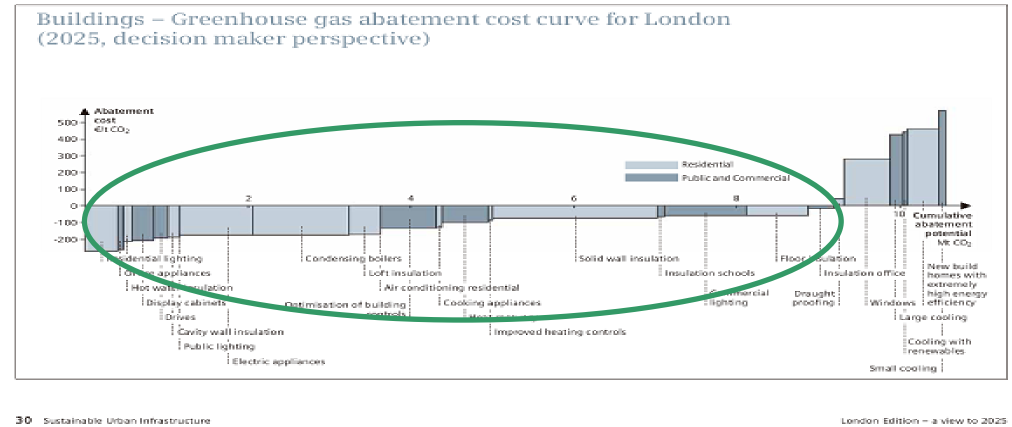
Prod./distrib. énergie

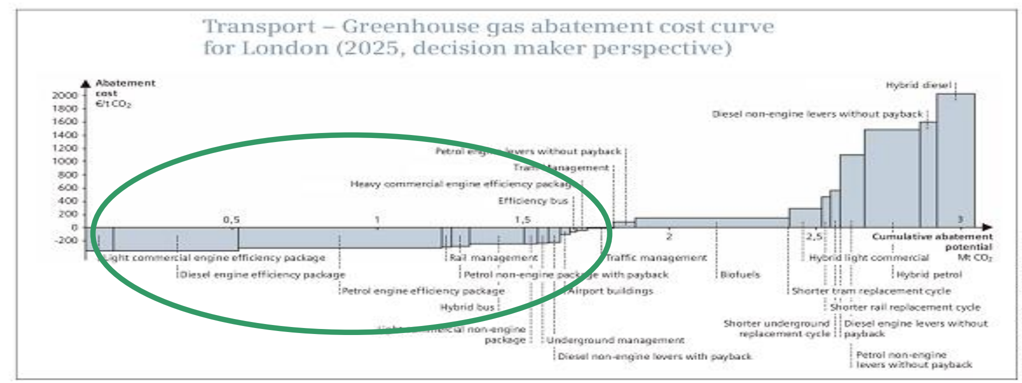
- Déchets
- Solaire BT / PV
- Biomasse
- Cogénération
- Réseaux chaleur/froid
- Smartgrids
- …/…

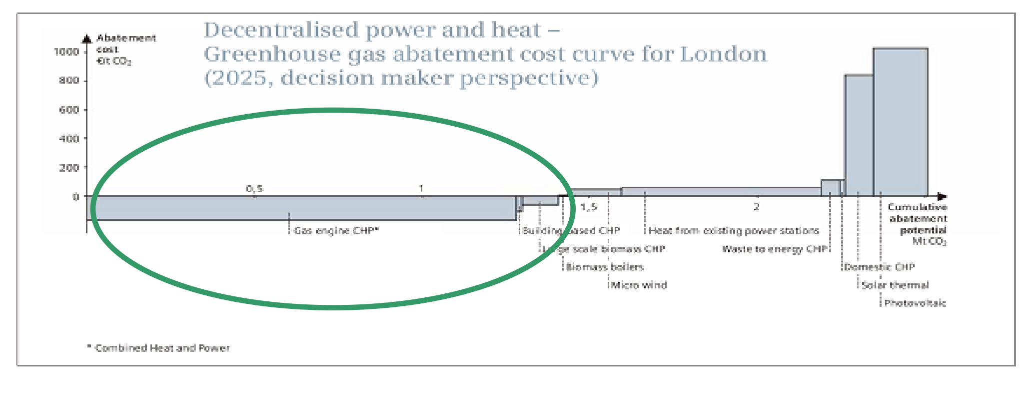
- Mais il est impossible d'ignorer la dimension systémique, en particulier dans les déterminants du transport

The SIEMENS-McKinsey study for London

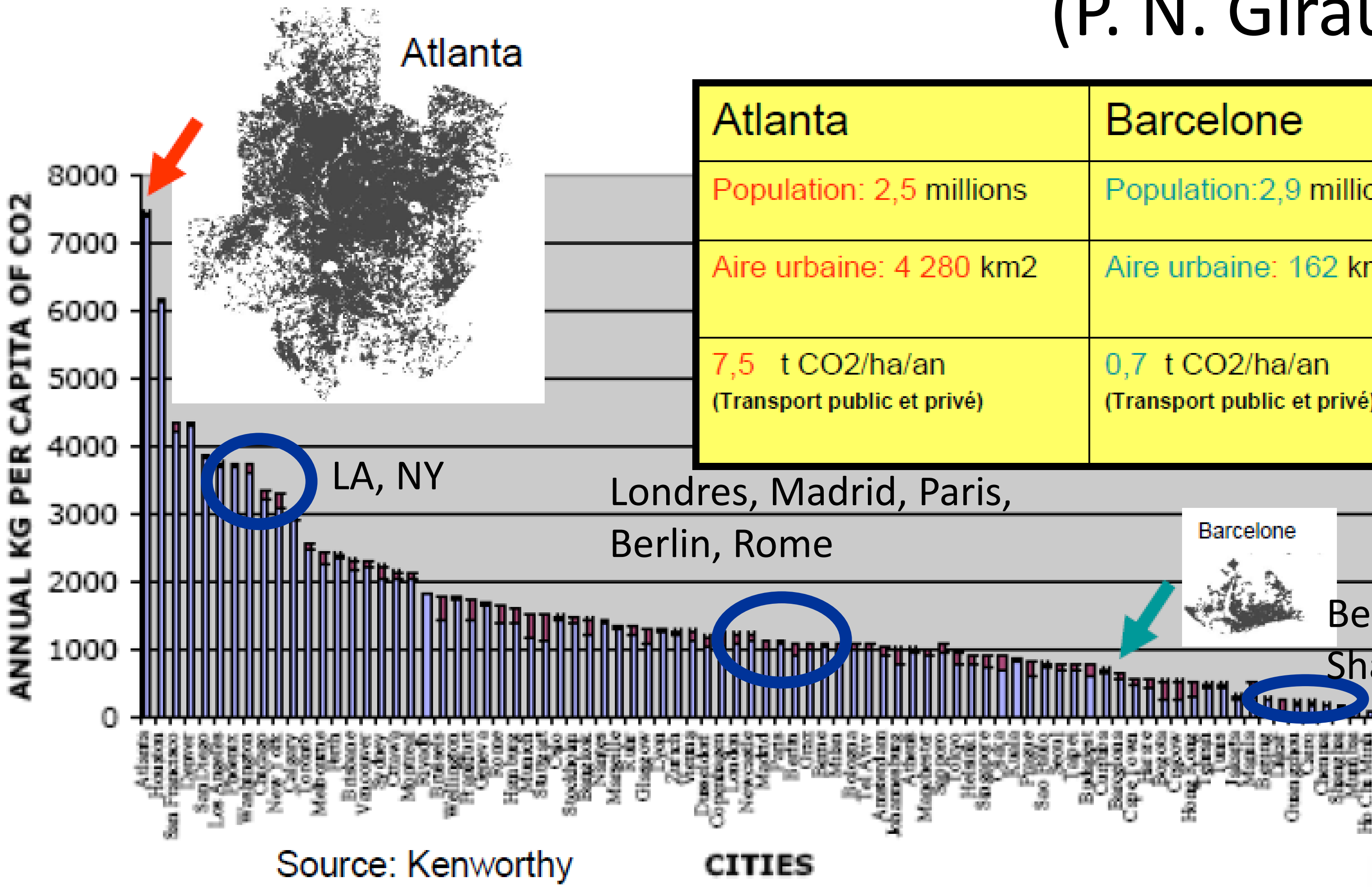
- Three main areas for incremental improvements and abatements:
  - Buildings
  - Transport
  - Local energy systems
- Negative costs or transaction costs ?







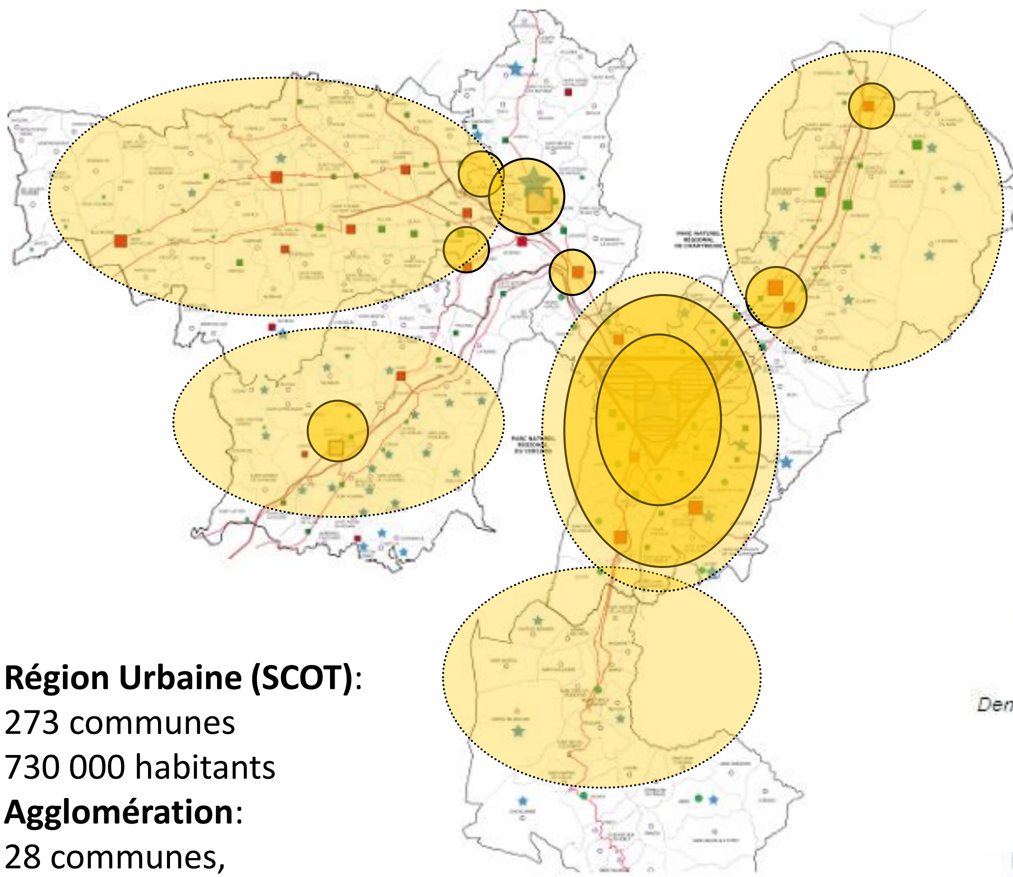
Ville bas carbone, la dimension systémique 1: densités urbaines et émissions des transports (P. N. Giraud)



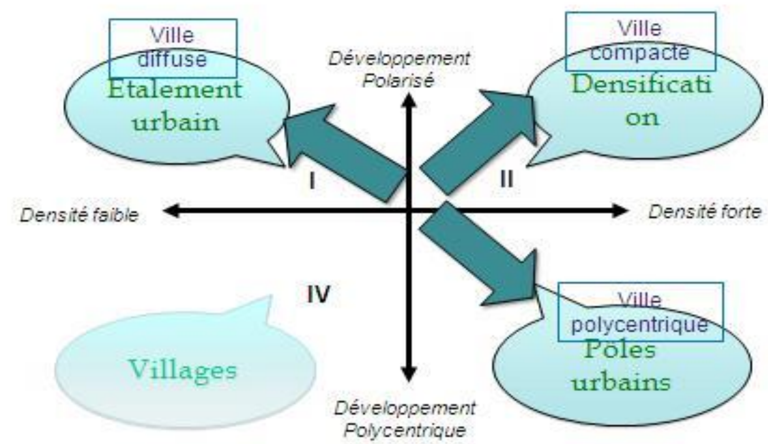
Atlanta	Barcelone
Population: 2,5 millions	Population:2,9 millions
Aire urbaine: 4 280 km2	Aire urbaine: 162 km2
7,5 t CO2/ha/an (Transport public et privé)	0,7 t CO2/ha/an (Transport public et privé)

Source: PN Giraud, B Lefevre

Trois scénarios contrastés de développement urbain pour la Région Urbaine de Grenoble en 2030



- S1 - concentration urbaine densification urbaine sur l'agglomération
- S2 - renforcement des pôles urbains et multipolarité (agglo + hors agglo)
- S3 - expansion urbaine par étalement (tendanciel)

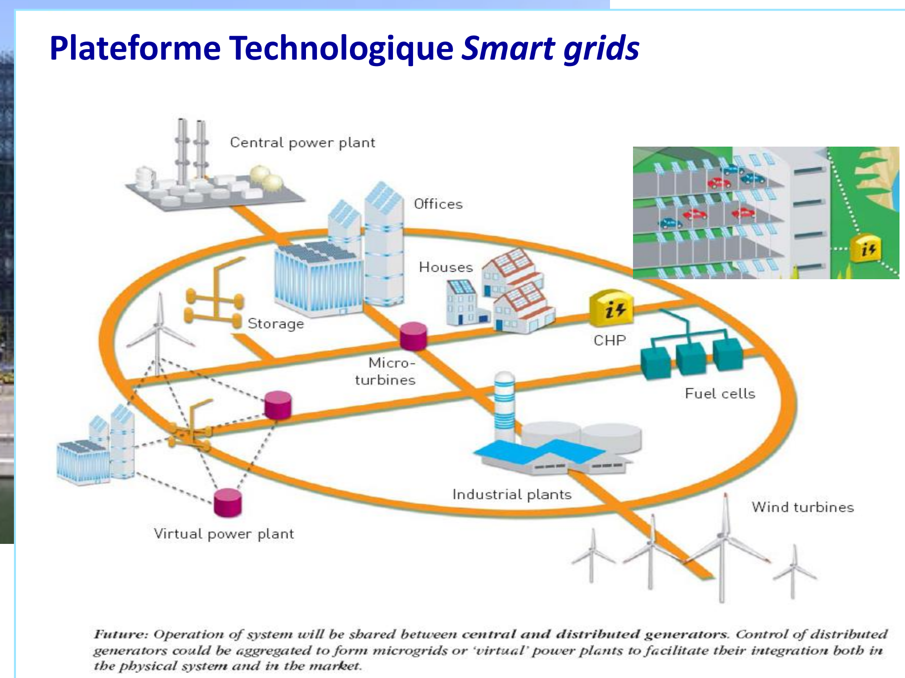


Région Urbaine (SCOT):
273 communes
730 000 habitants
Agglomération:
28 communes,
400 000 habitants

Positive-energy: back to physics

- Standard 100 sqm house: **23 000 kWh**
  - 20 000 kWh heat for comfort and HW
  - 3 000 kWh electricity for lighting, washing, electronics
- Low energy house + electric vehicle: **9 000 kWh**
  - 5 000 kWh for comfort and HW
  - 2 500 kWh for lighting, washing, electronics
  - 1 500 kWh for electric vehicle (15 000km/yr)
- Solar supply (50 sqm PV roof): **9 000 kWh**
  - 1 000 kWh/m2 x 18% (eff) x 50 m2
- With storage, this may provide a balance for an individual house, but not in a multi-storeys building…

Des canyons urbains aux éco-quartiers, ilots à énergie positive et à la "smart community"



Penser globalement et agir localement penser localement pour agir globalement

Global et international

Europe

France

Collectivités locales

- GIEC, Accord de Paris, DDPP
- Paquets Energie-Climat (gouverna Commission-Parlement-Conseil)
- Démo. délibérative (choix des futurs) et démo. représentative (moyens)
- Développement urbain bas carbone et démocratie locale participative