Dedicating multiscale approaches to low carbon prospective studies

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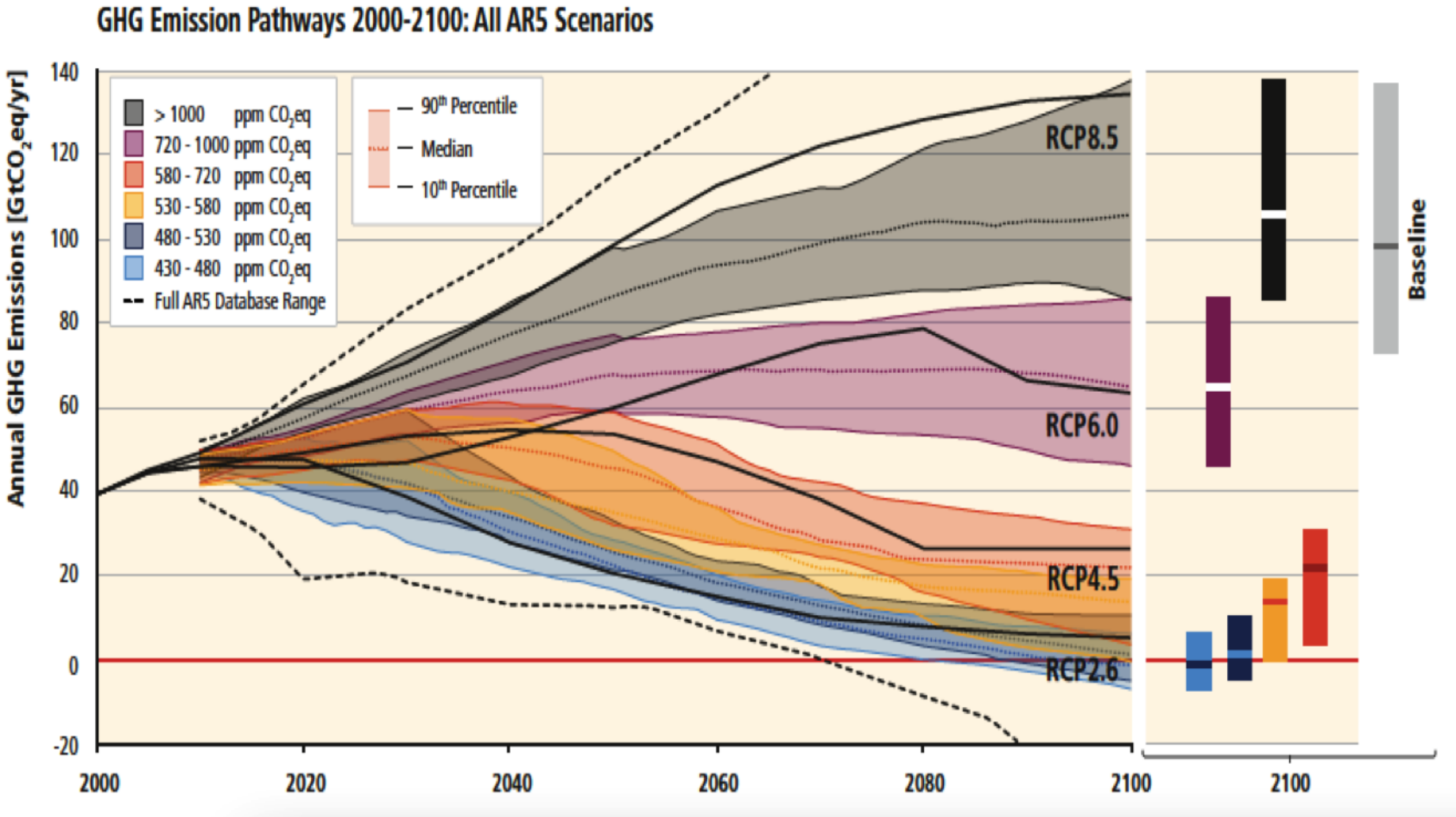
Science for energy scenarios, Les Houches, 2016

IPCC long term scenarios scenarios : what do they tell ?



Source : IPCC, 2014: Summary for Policymakers

Where do they come from ? : 900 scenarios

"There are multiple scenarios with a range of technological and behavioral options, with different characteristics and implications for sustainable development, that are consistent with different levels of mitigation. For this assessment, about 900 mitigation scenarios have been collected in a database based on published integrated models."

(IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.)

Profusion of global trajectories that finally erase

1. urgency and uncertainty
2. local realities

Scenarios for the Future

☞ are misunderstood if interpreted with no indication about

- their position regarding the future
- the keys to connecting trajectories with reality : i.e. the ability to open the black boxes

The Chair Modelling for sustainable development (Chaire Modélisation Prospective au service du développement durable) is the framework in which these questions are addressed.

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Position regarding the future

Whilst Prediction **imposes** the future,

Prospective

- **envisions** all the possible futures
- in order to **lighten** tomorrow's consequences of today's choices and decisions

In other words Prospective exercises enable to :

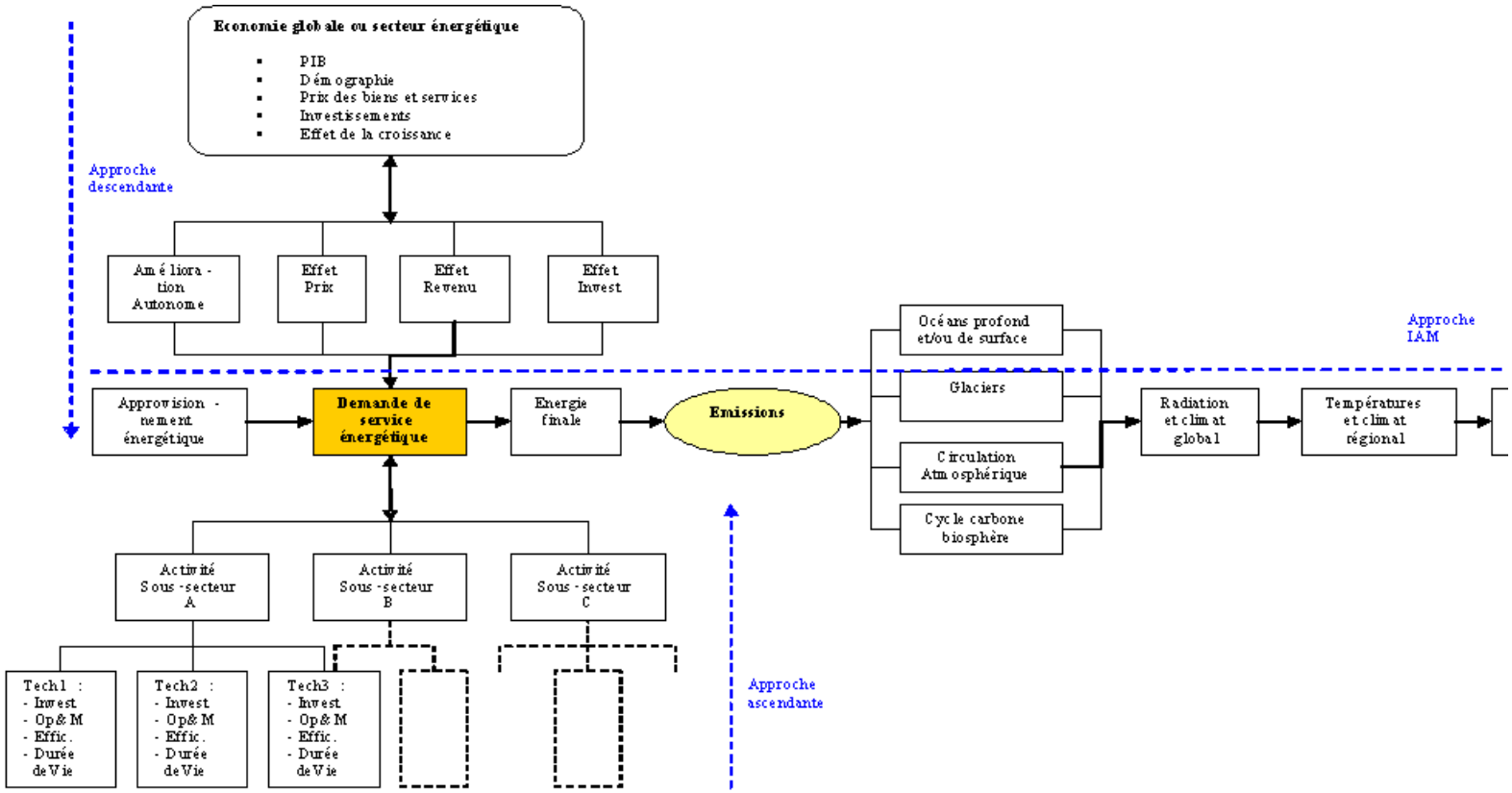
- **be prepared** to unexpected trends or events thanks to the assessment of a **diversity of imagined futures**
- i.e. **to build a prosthesis** for the stake-holders or decision-makers who desire a **calculated adventure**

Pierre Massé

☞ Tools are needed to think, debate, and to evaluate decisions and measures

Scenarios are meaningful

☞ according to the adopted predominance given to **economics, technology or climate**, the models that have generated are based on



Source AIE et Parson & Fisher-Vanden & Assoumou (2005)

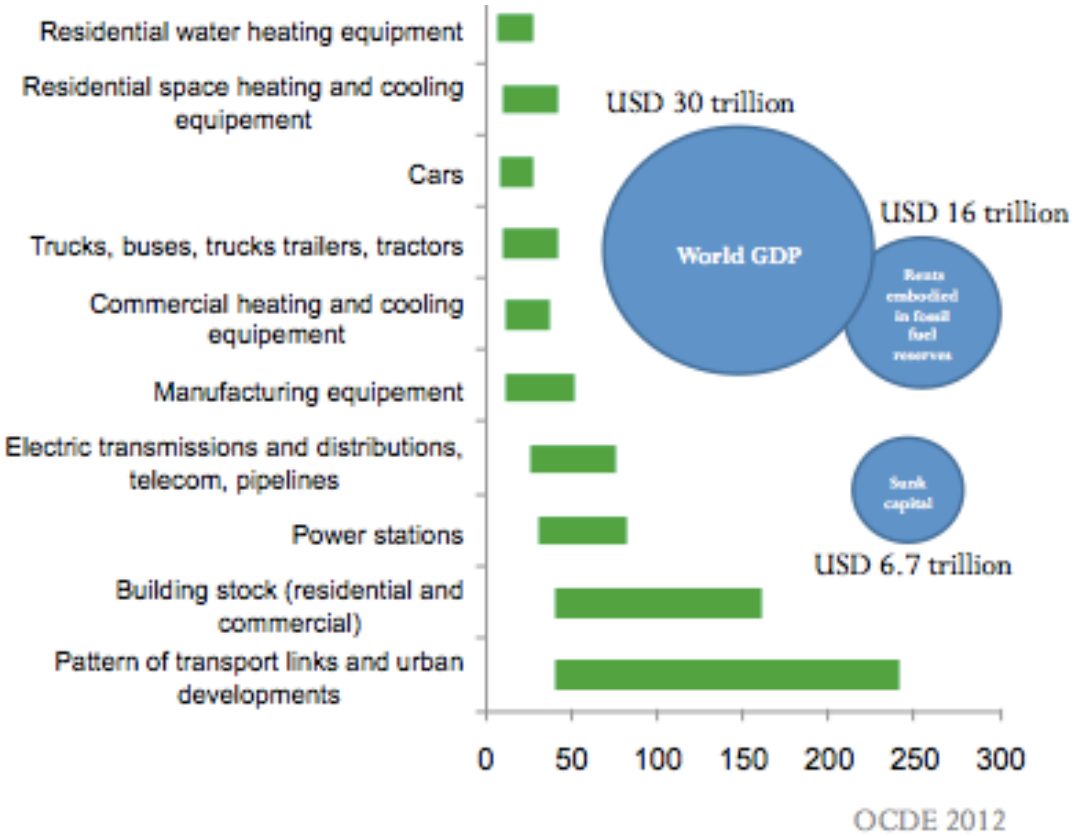
The class of techno-economical models

TECHNO-ECONOMICAL MODELS

TECHNICAL	ECONOMIC
energy sector disaggregated	energy sector aggregated
deviations permitted regarding historical trends	no possible deviation regarding historical trends
energy = function (efficiency, usage) energy units	energy = function (GDP, price, inflation) monetary units

Productivim and investments Inertia

Energy sector is responsible of **two third** of the world global GHG emissions (AIE 2015).



Lifespan of capital investments (OCDE 2012)

Solutions to combate climate change in the energy sector

We witnessed a thematic renewal that has evolved over the last decade

1. opening up Europe's electricity and gas markets.
2. industrial ecology, energy efficiency, the green economy, green growth, degrowth and carbon finance, greater energy efficiency
3. first-, second- or third-generation biofuels, biomass, solar, wind and marine power (waves, marine turbines, etc.), geothermal energy, etc.
4. technological solutions : storage facilities (step, batteries, flywheel etc.)., flexibility (aggregation, virtual power plants, smart energy, smart grids, smart cities, smart buildings, etc.).

TIMES as a Prospective tool

"What we have the right to ask a conceptual model is that is seize on the strategic relationships that control the phenomenon it describes and that it thereby permit us to manipulate, i.e., **think about the situation**"

Source: R. Dorfman, P. A. Samuelson,R. M. Solow

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Optimal paradigm: the planner

$$\min_{x \in X} f(x)$$

x decision variable

X feasible set of solutions

f objective function

Based on an optimality paradigm

derived from **von Neumann** (1930) and **Sraffa**

☞ *How much should a nation save ?*

The objective

establish a production plan (programme) $x_1, ..., x_n$ *in order to minimize the production cost taking into account the potentiels of the production factors and driven by a demand*

The plan is formulated as follows

$$\min_{x_j} z = \sum_{j=1}^{n} c_j x_j$$

$$\sum_{j=1}^{n} a_{ij} x_j \leqslant b_i \quad i = 1, ..., m \qquad x_j \geqslant 0 \quad j = 1, ..., n$$

$$\sum_{j} a_{ij} x_j \geqslant D$$

Competitions, substitutions and coherence

TIMES

A technical linear optimization model, **open-source** developed in the framework of **ETSAP**: Energy Technology Systems Analysis Program initiated by the IEA (in 1980)

- demand driven
- on a long term horizon: (50/100 years)
- in order to achieve **a technico-economic optimum** minimizing the overall actualized cost of the reference energy system

1. whose flows are balanced
2. satisfying a set of relevant technical constraints (peak reserve for the power system,. . .)

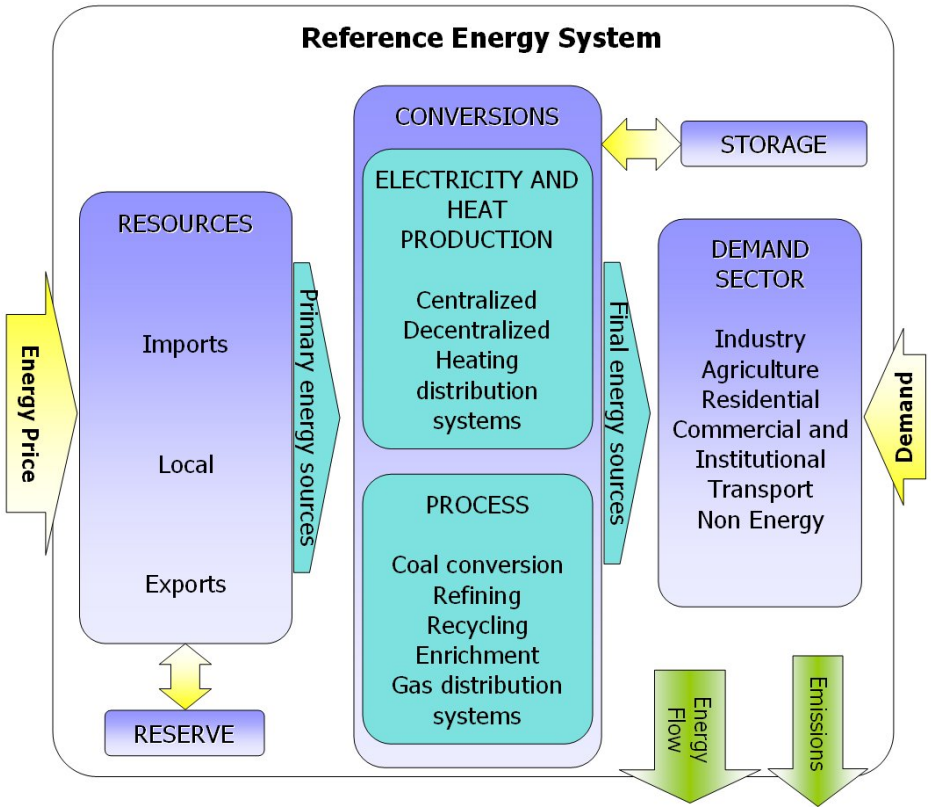

Figure : The Integrated MarkAl (market allocation)-EFOM Reference Energy System (cultural transformation part)

The use of scenarios: prospective versus prediction

Energy planning modelling through TIMES enables to:

- **envision** all the possible futures
- in order to **lighten** tomorrow's consequences of today's choices and decisions

- Instead of using **scenarios kept in a stock**

- each question requires **a flow of dedicated scenarios**, to assess a future energy systems

Desirable, Plausible, Sustainable

Multi-scale integration : mandatory

In order to identify long-term strategies relevant to all types of climate constraints (e.g. climate-related, financial, legal, political, technical) we propose to **reconcile and connect different scales (temporal, spatial, social)** :

1. **Time reconciliation** The impact of phenomena with different dynamics (several decades versus seconds)
2. **Space aggregation** The political implications that necessarily take place at several levels, from global to local
3. **Financial scale** where we evaluate how carbon finance tools (especially taxes and carbon market) could contribute to both reduce the volume of carbon dioxyde emissions and encourage the use of renewable sources along with energy efficiency policies.
4. **Societal scales** The central role of people (for whom the future must be acceptable and desirable, i.e. compatible with aspirations and behavior)

Spatial scale: regional issues

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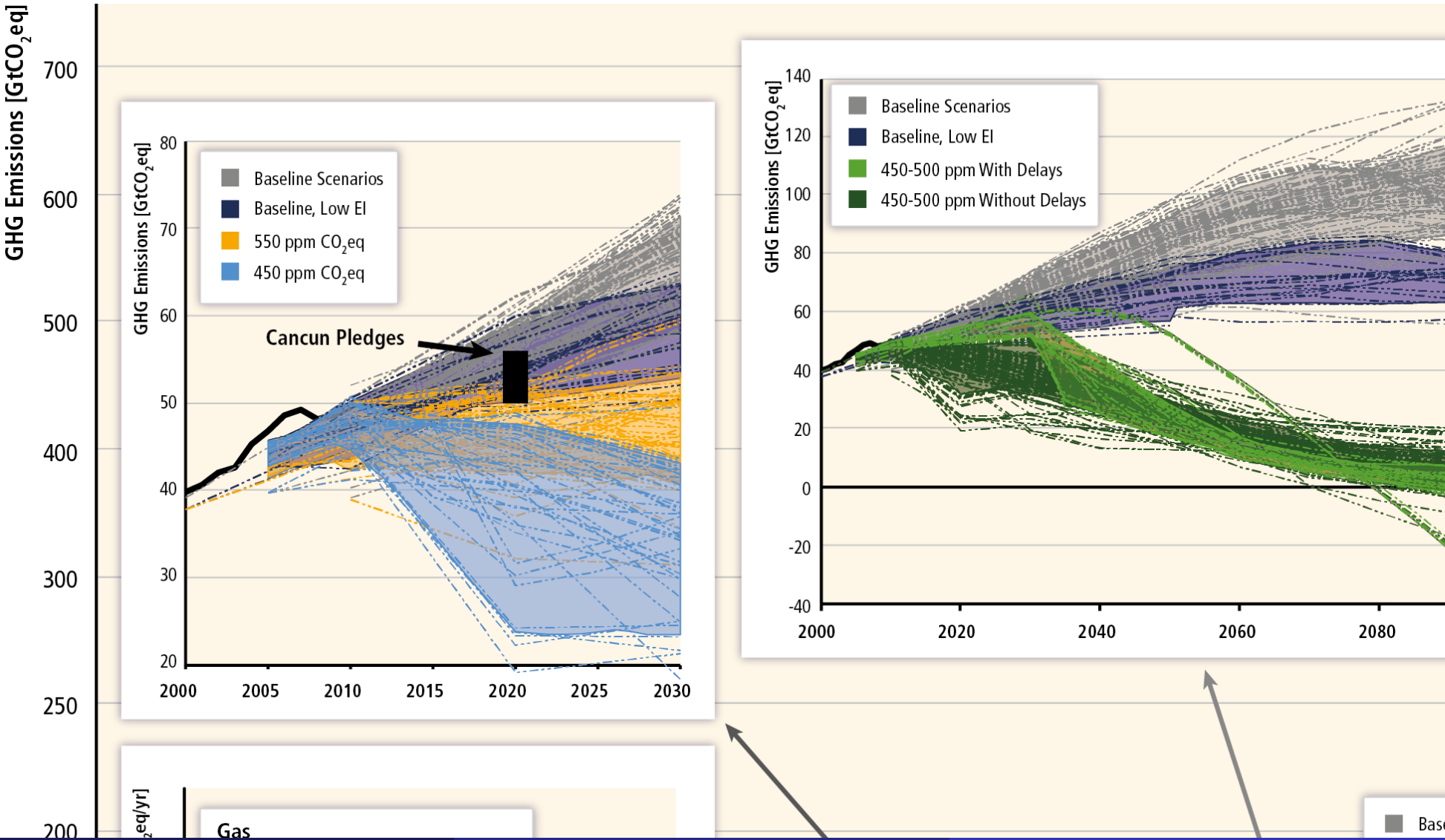
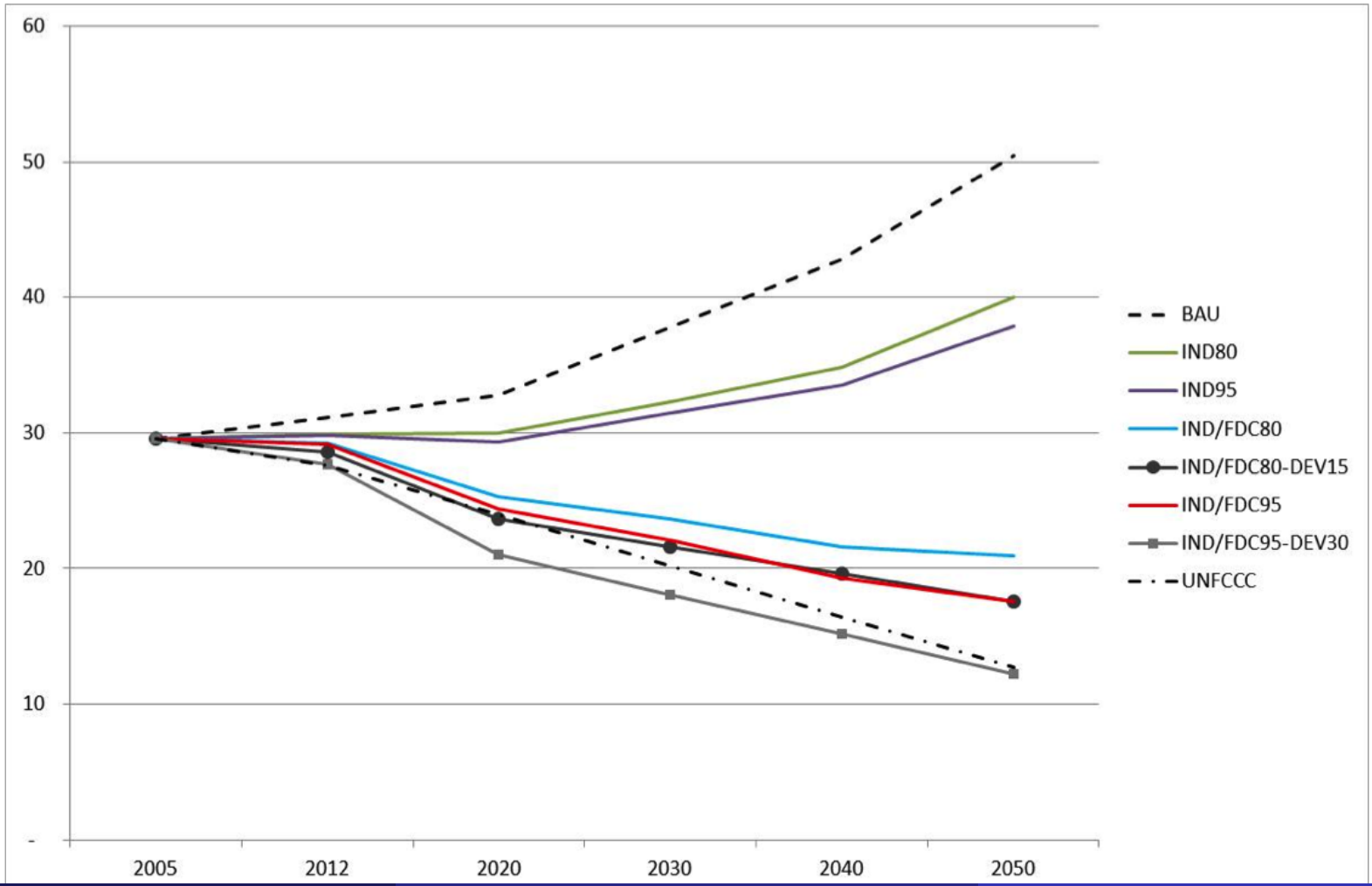
Back to IPCC : opening the black boxes



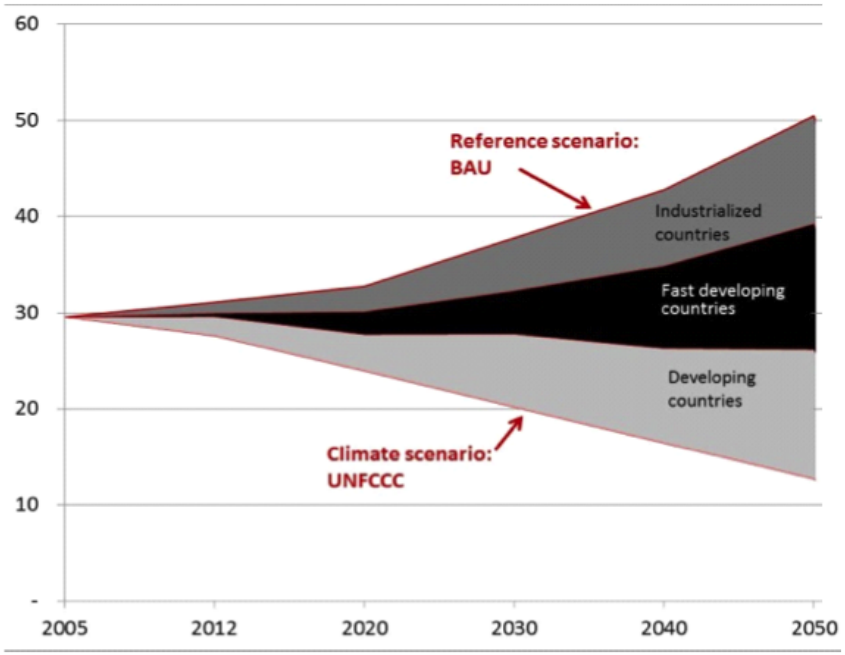
Focusing on energy scenarios towards 2050

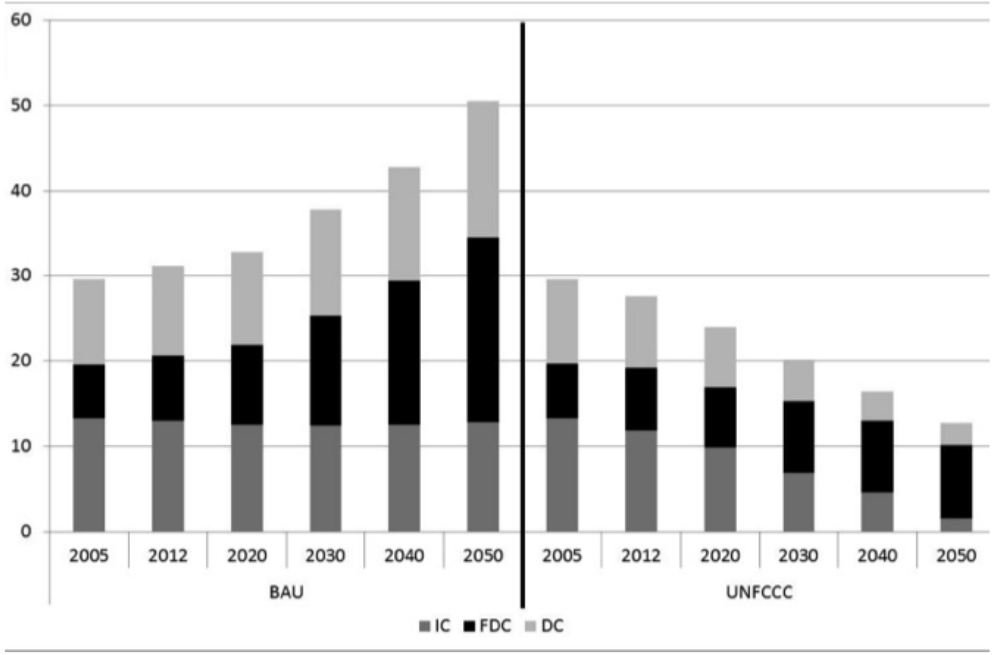
S. Selosse, N. Maïzi, What commitments for the future climate regime: Long-term decoding using TIAM-FR, IEW Beijing 2014.



Top Down options to reach the 2°C target

S. Selosse, N. Maïzi, What commitments for the future climate regime: Long-term decoding using TIAM-FR, IEW Beijing 2014.

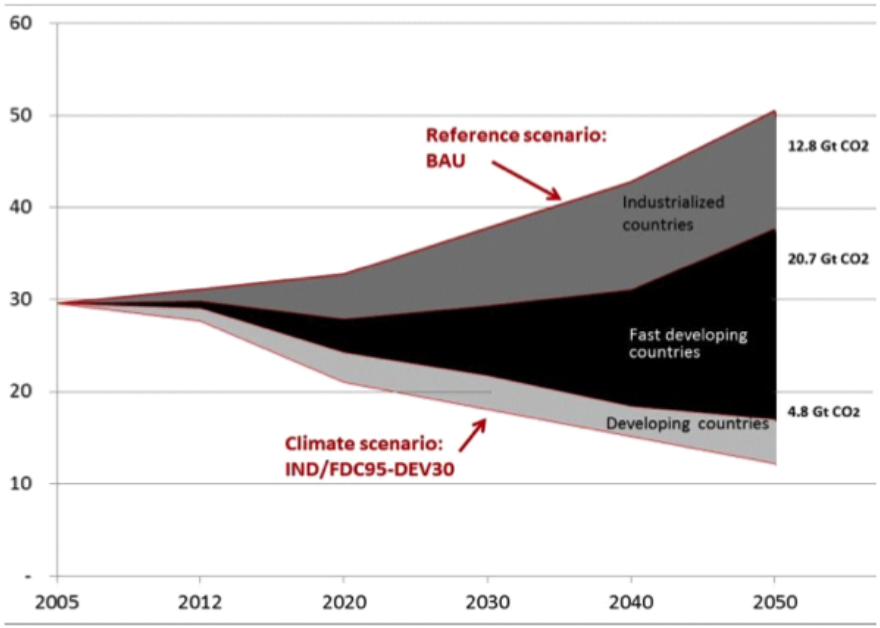


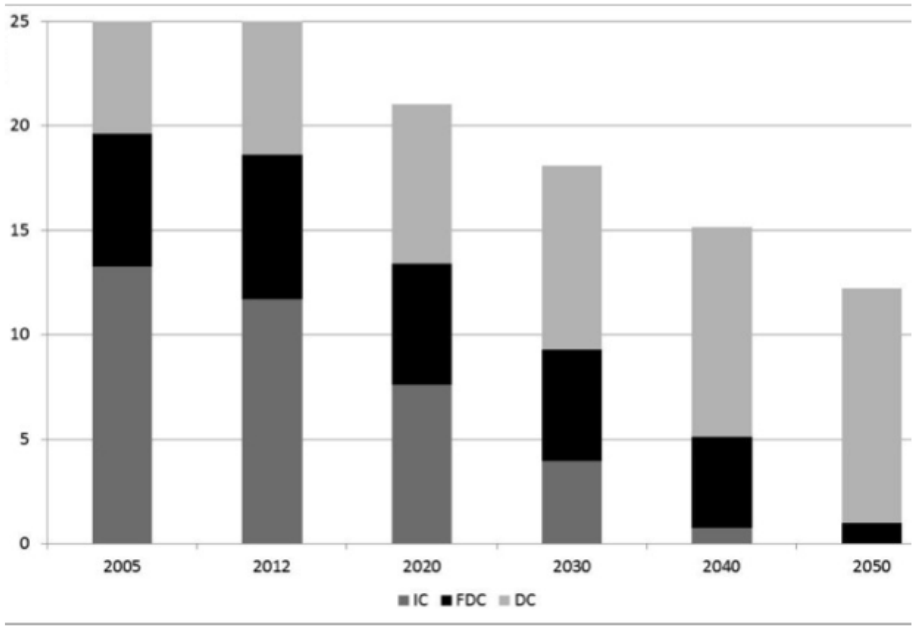


Burden for DC: they have to mitigate up to 84% compare to BAU

Pledges options to reach the 2°C

S. Selosse, N. Maïzi, What commitments for the future climate regime: Long-term decoding using TIAM-FR, IEW Beijing 2014.

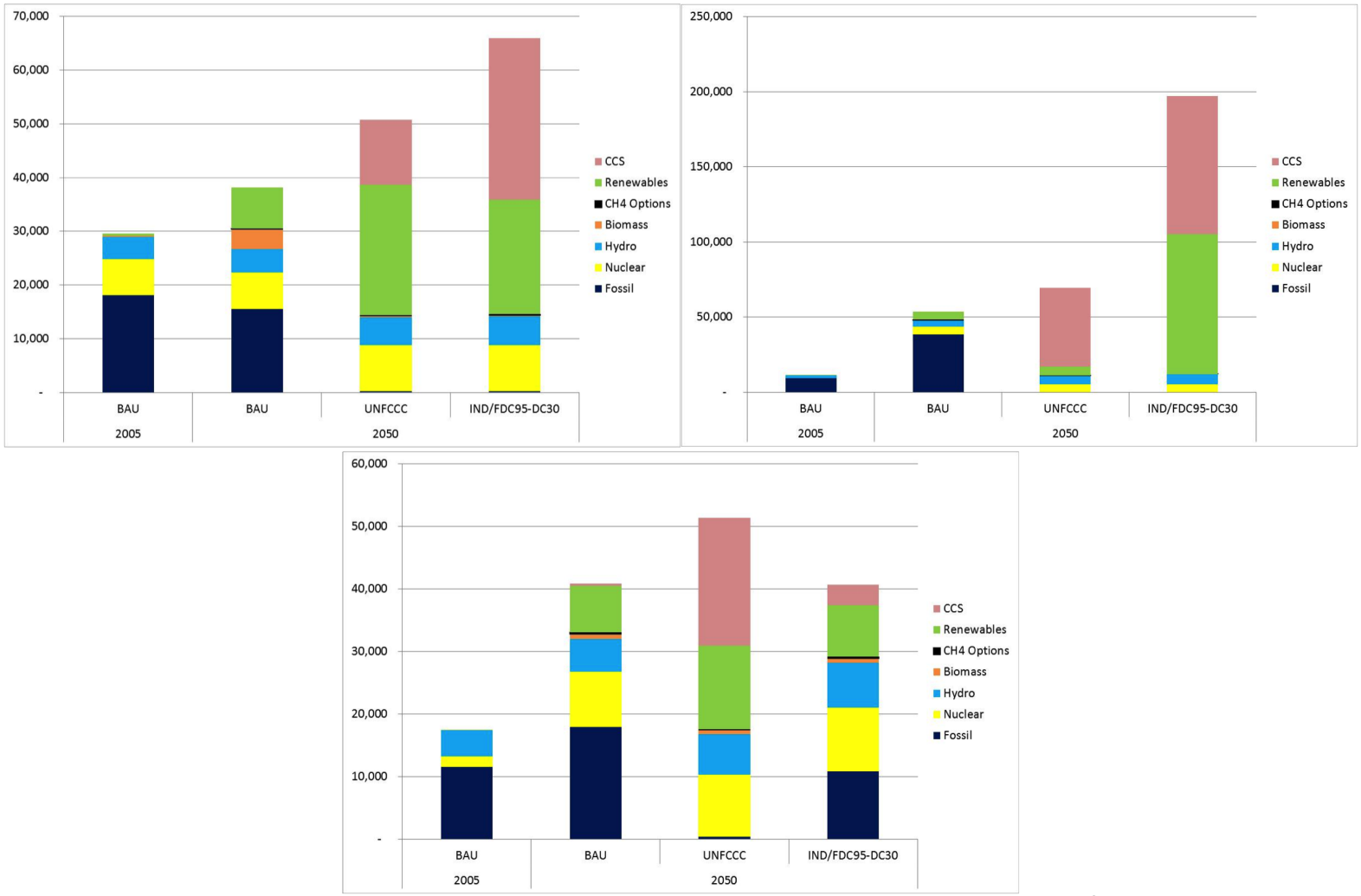




Burden for DC: they have to mitigate up to 30% compare to BAU

Realism for regional technological options

Regional view of the power mix from left to right IC and FDC, bottom DC



[S. Selosse , O. Ricci, Achieving negative emissions in the power sector: New insights from the TIAM-FR model, in proc. Climatic Change, 2014]

Societal scale: behavior

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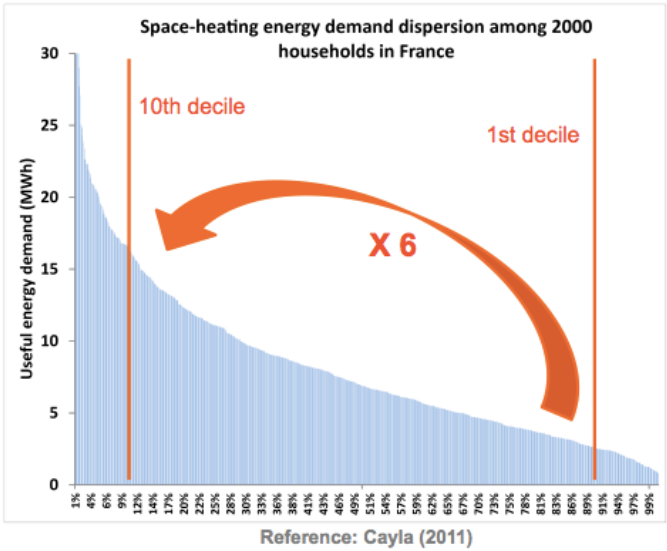
Households heterogeneity explains behavior

J.-M. Cayla, N. Maïzi, C. Marchand, "The Role of Income in Energy Consumption Behaviour: Evidence from French Households data", Energy Policy, Volume 39, Issue 12, December 2011, Pages 7874-7883.

☞ Importance of households behavior in energy consumption (2009 survey on 2000 French households related to housing, climate, household characteristics and their space-heating practices in addition to their energy bill:)

variables linked to housing characteristics represent around 66% of explained dispersion (half of it) in space-heating energy demand whereas variables linked to inhabitants represent about 33%. (Cayla 2010).

- Great dispersion between households:
  factor 6 between extreme deciles
  depending on
  - Thermal quality of housing
  - Space living area
  - Type of heating system (boiler, heat pumps?)
  - Climatic variable
  - Household behavior...



TIMES-Households model: integrating individual behavior

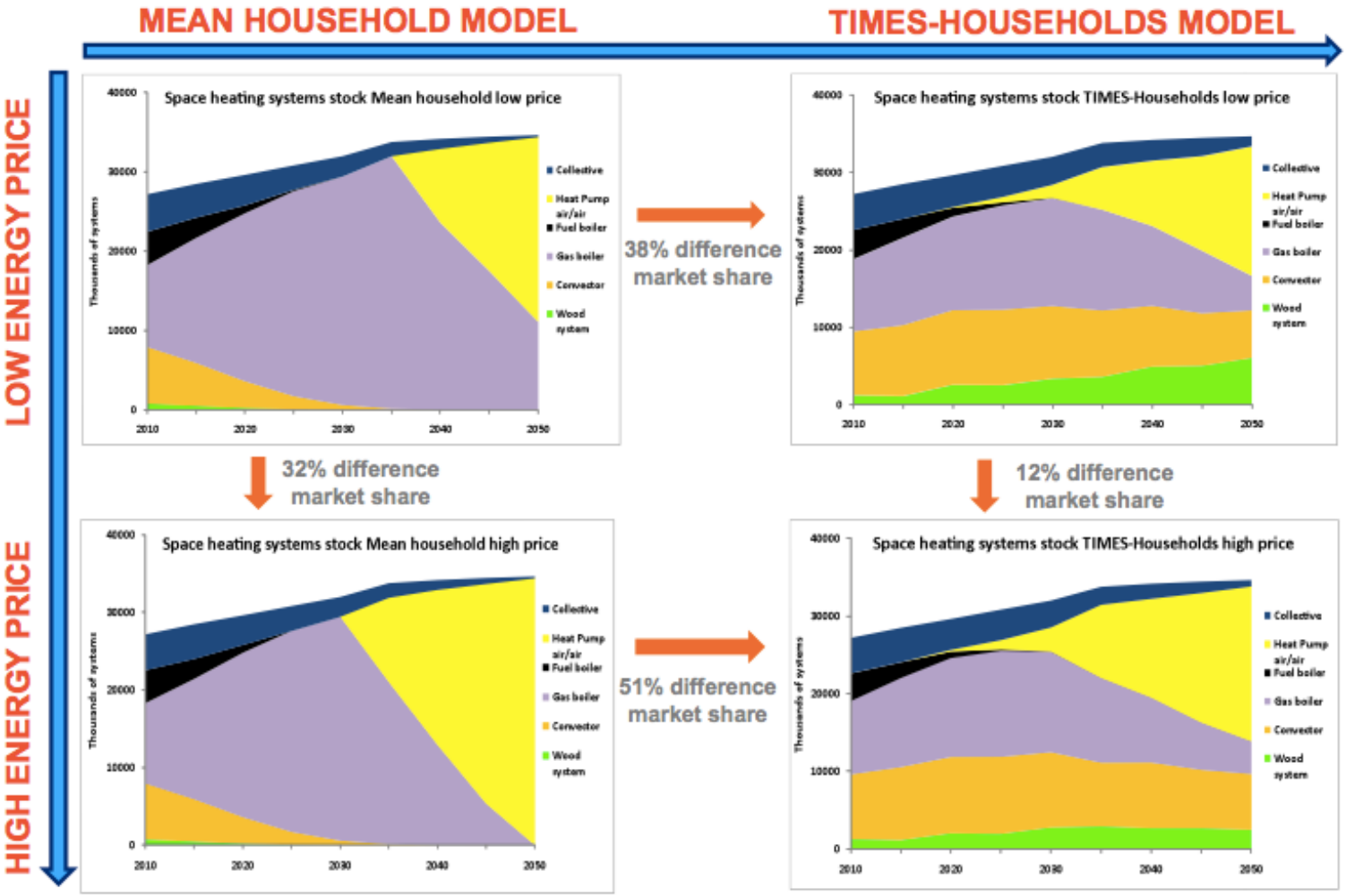
180 segments to encapsulate heterogeneity and behavior in energy models were defined according to

- Access to available technologies
  - Size of car depends on household size
  - Access to collective transports (subway, bus) depends on location
  - Solar water heating systems are available only for houses
  - Thermal insulation are available only for owners
- Level of energy services consumed
  - Space heating need depends on thermal insulation, space living area, income
  - Water heating need depends on household size
  - Number of trips depends on activity status
  - Length of trips depends on location
- Preferences for equipments
  - Required rate of return depends on income and type of equipment
  - Maximum amount of investment in equipments depends on income

[J.-M. Cayla and N. Maïzi. Integrating behavior and heterogeneity into the TIMES-households model. Applied Energy (2015) vol. 139 pp 56-67.]

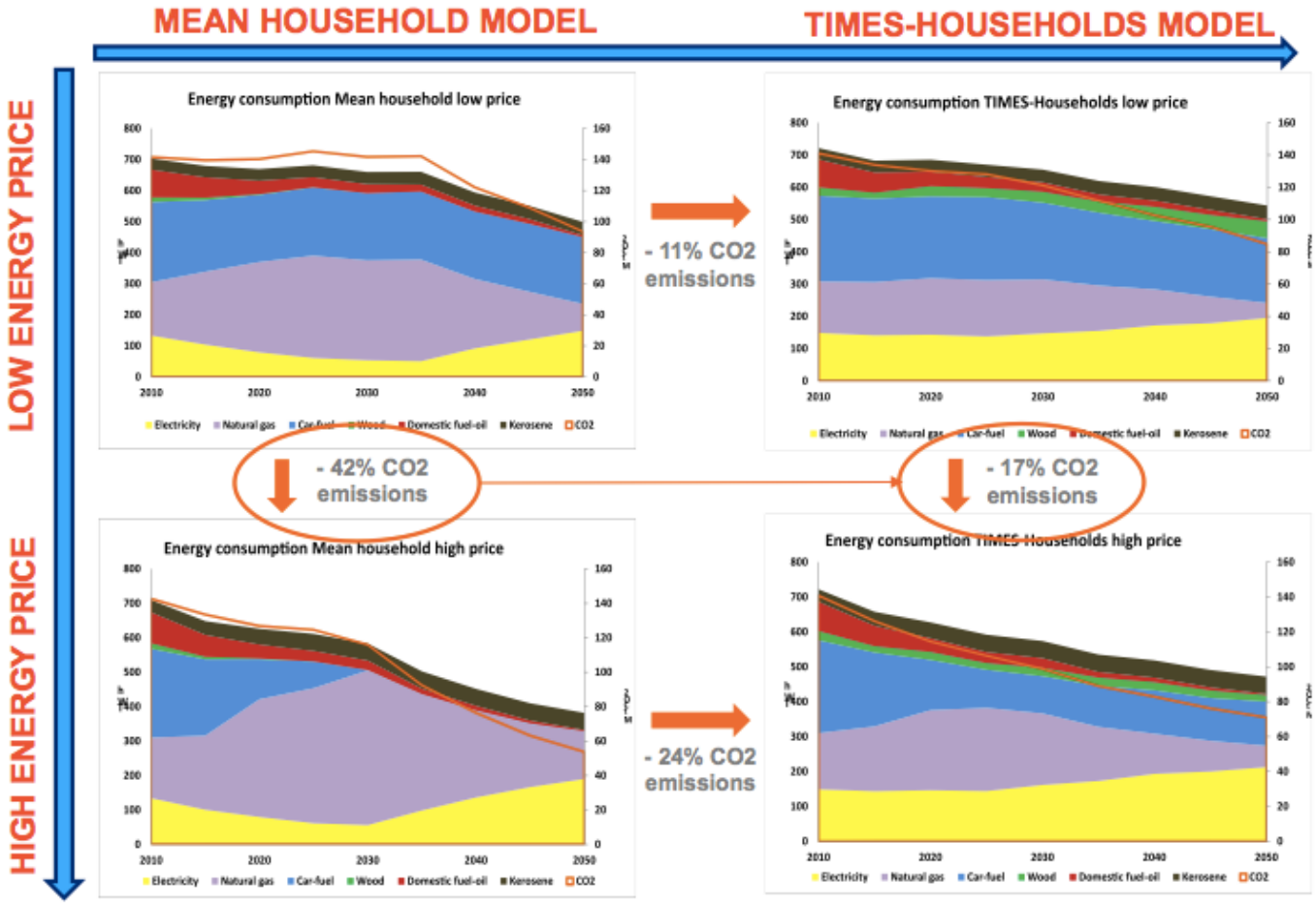
Technology diffusion in residential sector

Model provides more realistic technology diffusion patterns & answers to energy price variations
[J.-M. Cayla and N. Maïzi. Integrating behavior and heterogeneity into the TIMES-households model. Applied Energy (2015) vol. 139 pp 56-67.]



Energy and CO_2 emissions for residential/transports sectors

Implications in terms of Technology and policy recommendations when energy models are over-simplified may be dramatic



Source: Cayla & Maïzi (2015)

Conclusion for behavior issues

- Household behavior explains a large part of energy consumption
- Technological change may surely not be sufficient to reach ambitious (but needed ?) CO2 emissions reduction pathways
- There is a need to consider, understand and include household behavior in long-term energy models
- Considering households heterogeneity is a required first step in order to correctly catch household behavior as it greatly varies accross households
- Modeling household behavior would help to better understand and design adapted policy measures: improve economic efficiency and acceptability, solve equity issues
- There is a need to keep improving behavioural realism and its impacts on energy consumption in long-term energy models

[J.-M. Cayla and N. Maïzi. Integrating behavior and heterogeneity into the TIMES-households model. Applied Energy (2015) vol. 139 pp 56-67.]

Societal scale: degrowth paradigm

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Degrowth

- NOT GDP degrowth per se
- A project of transition toward a society of « frugal abundance » (S.Latouche)
- A « matrix » for multiple alternatives

Source: « *Degrowth, a vocabulary for a new era* » Routledge 2014

Ambition:

A voluntary , democratic, socially sustainable, equitable, smooth downscaling of production and consumption for high consumption countries, to an environmentally sustainable level

Degrowth concept issues

☞ GDP degrowth is a plausible consequence of Degrowth

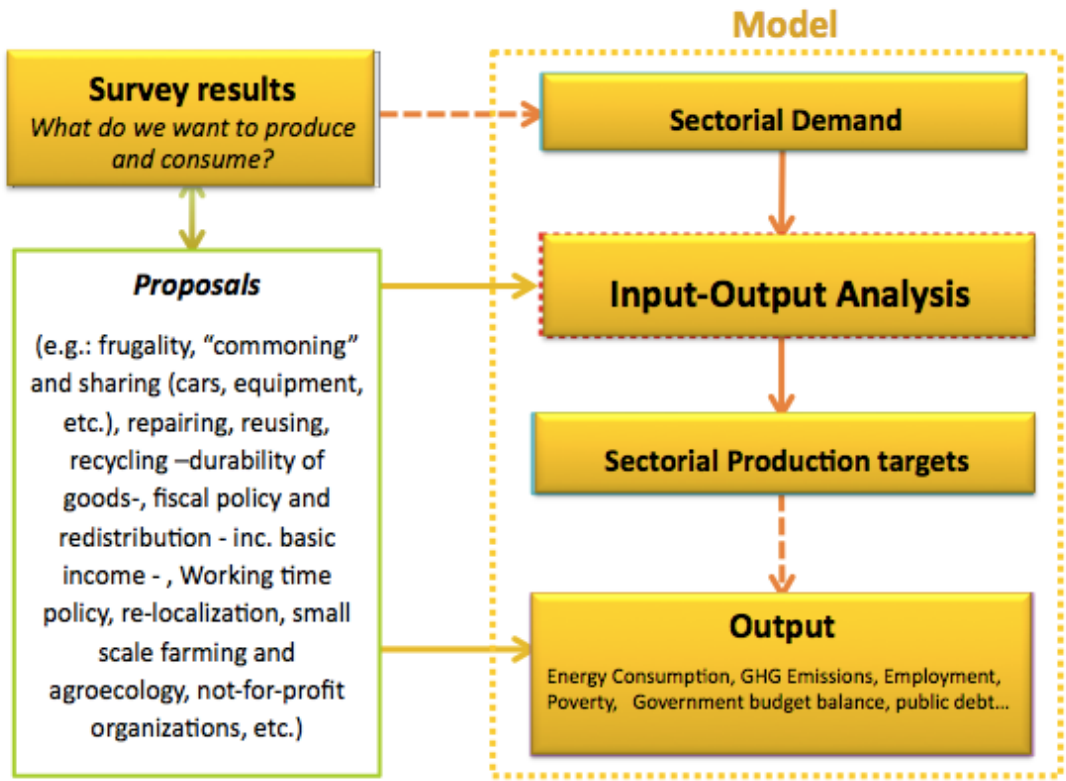
- Can it happen in a socially and environmentally sustainable way?
- Under which conditions? (any institutional or structural obstacles?)
- Which concrete proposals could enable a sustainable Degrowth?
- Welfare state in a degrown economy?

☞ What can prospective modeling tell us?

[F. Briens, N. Maïzi, Coping with the complexity of socio-ecological systems : Investigating the Degrowth Paradigm through prospective Modeling, ÖkologischesWirtschaften 3.2014 (29)]

Back to model: in a nutshell

- Input-Output Dynamic Simulation Model (based on STELLA)
- Based on public data (French National Accounts (Insee), Eurostat, WIOD , etc.)
- Focus on structural relationships, long term concern (rather than conjonctural issues)



[F. Briens, La décroissance au prisme de la modélisation prospective : exploration macroéconomique d'une alternative paradigmatique, PhD thesis, December 2015]

Survey result

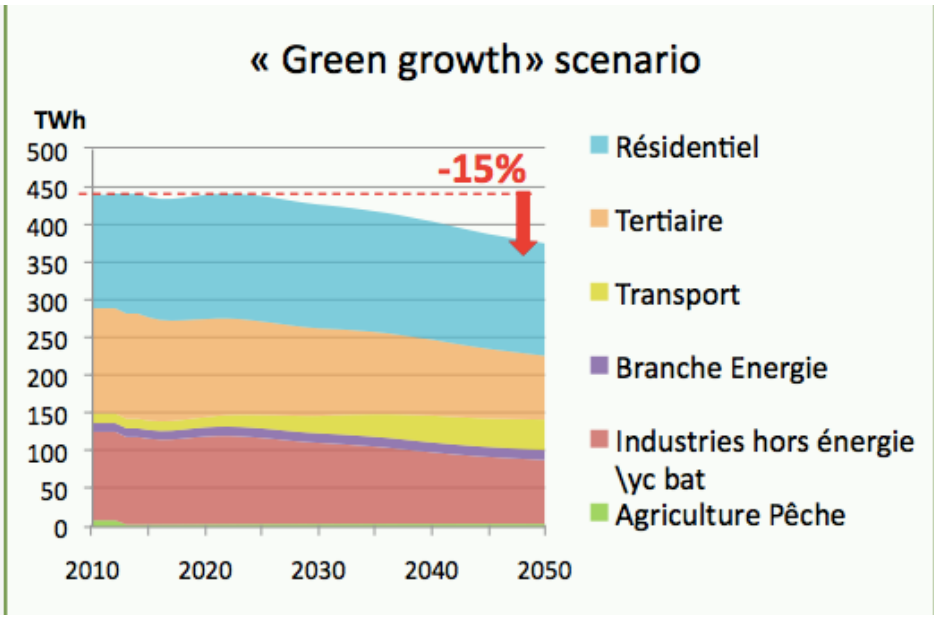
One example of a scenario built after an interview:

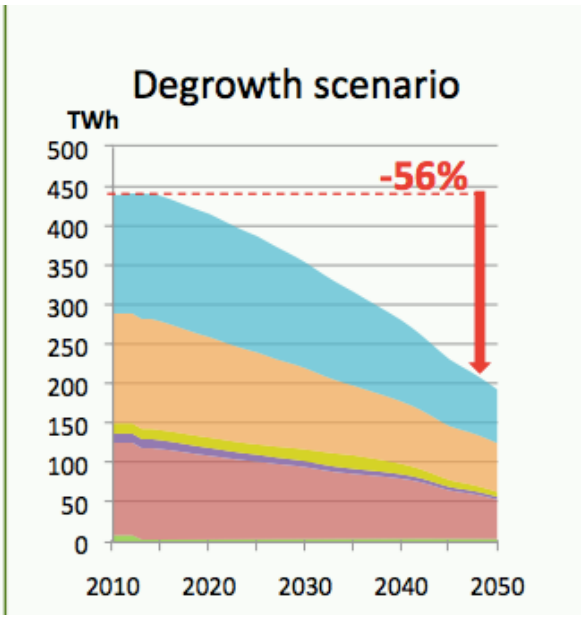
- Changes in consumption of various goods services
- Switch to more vegan food 100% organic farming by 2050
- Changes in mobility and modal shares
- Relocalization
- Changes in cohabitation behaviors
- Decrease in Working time (35-> 24h by 2050)
- Slow down in efficiency improvement rates until 2040
- 100% Renewable Energy by 2050 (with reduced network stability) Etc.

[F. Briens, PhD thesis, Dec 2015]

Scenario results for France

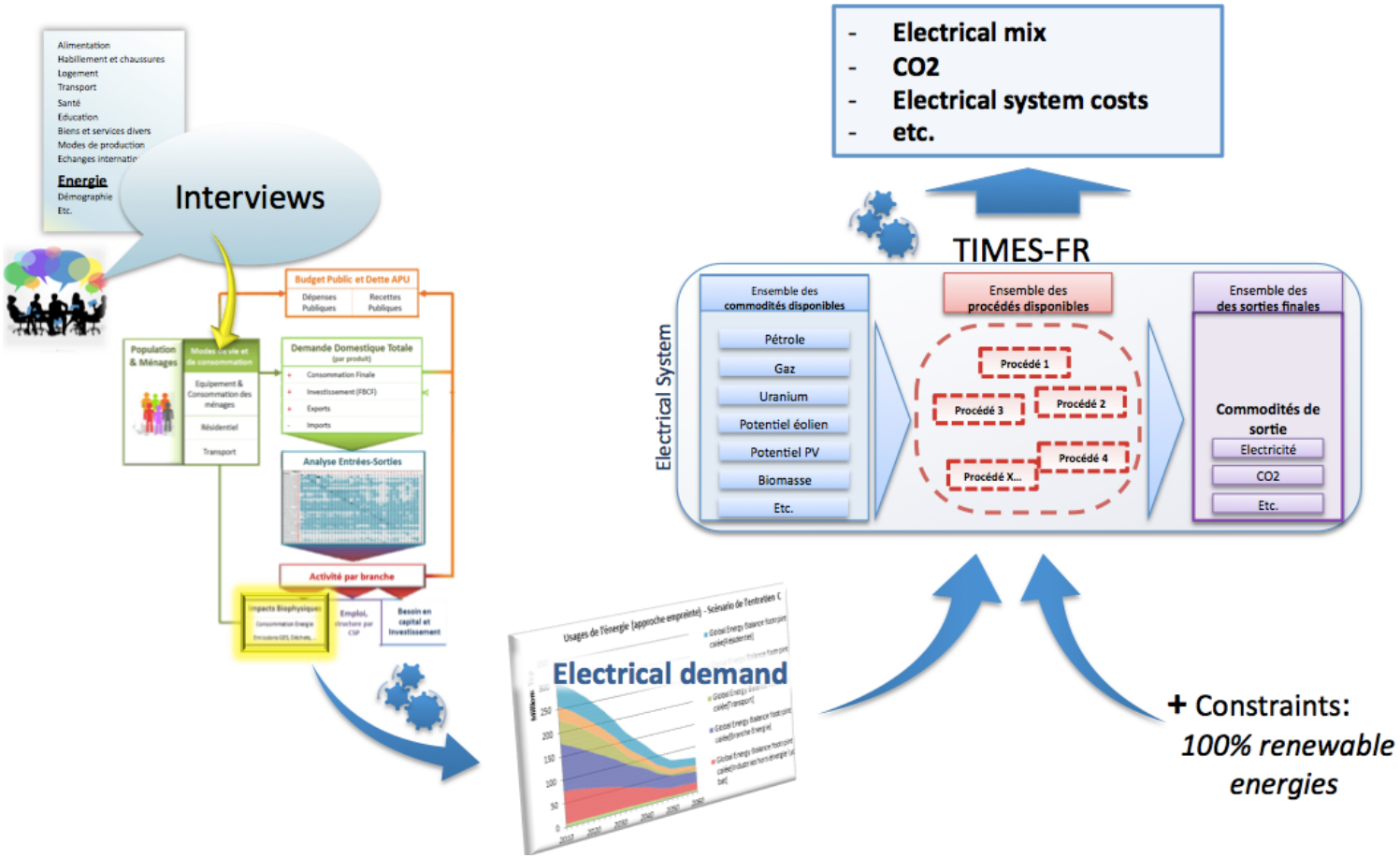
Demand
=>output of macro economical simulation





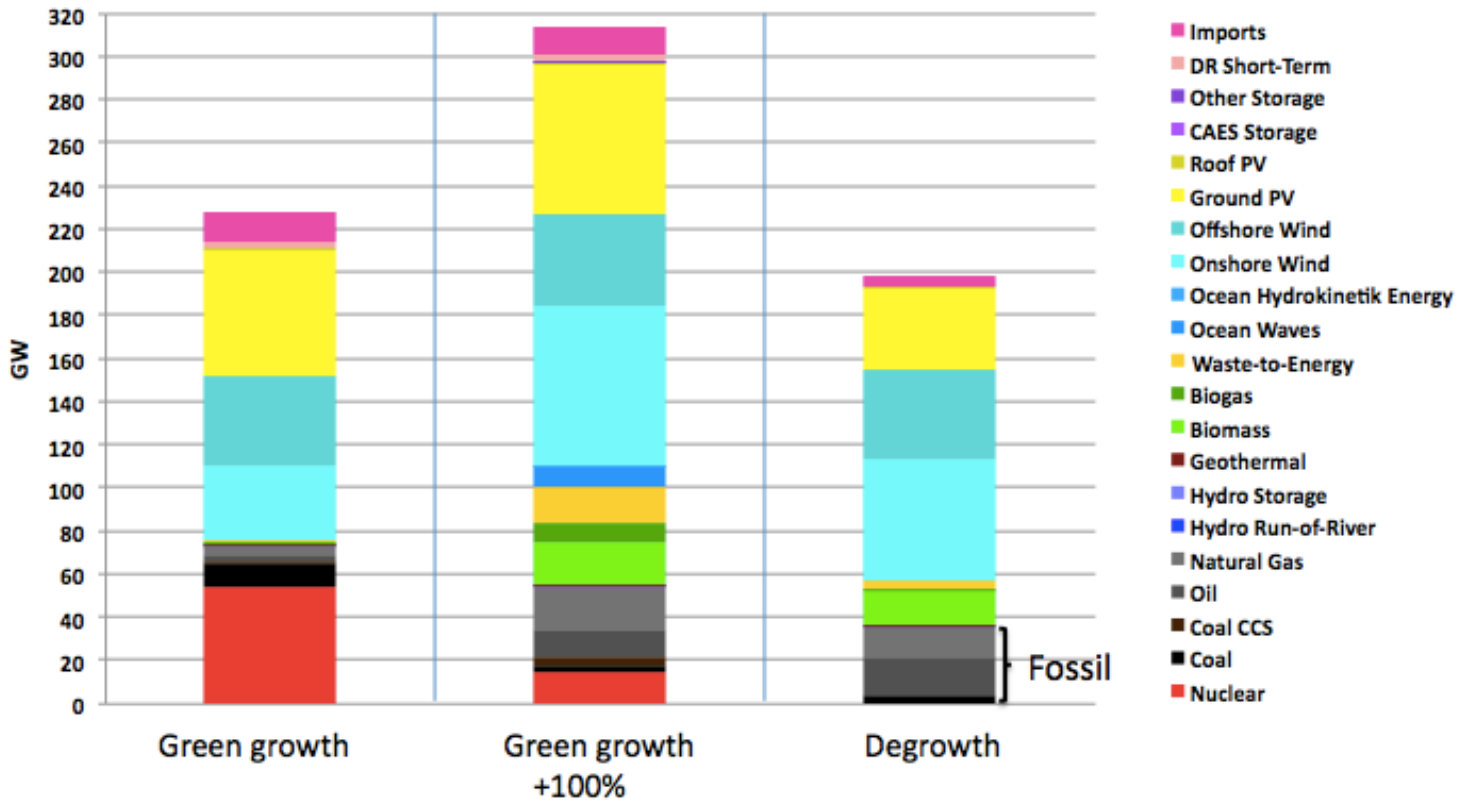
[F. Briens, PhD thesis, Dec 2015]

Linking degrowth and energy



[F. Briens, PhD thesis, Dec 2015]

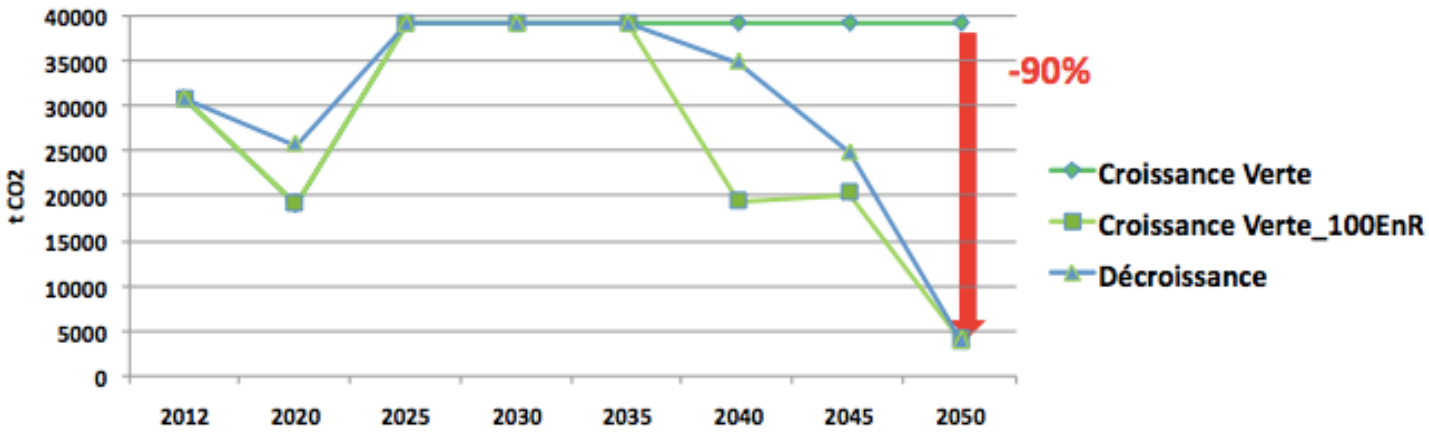
New capacities investments for the power system



Gaz and Coal are mandatory to phase-out from nuclear.

[F. Briens, PhD thesis, Dec 2015]

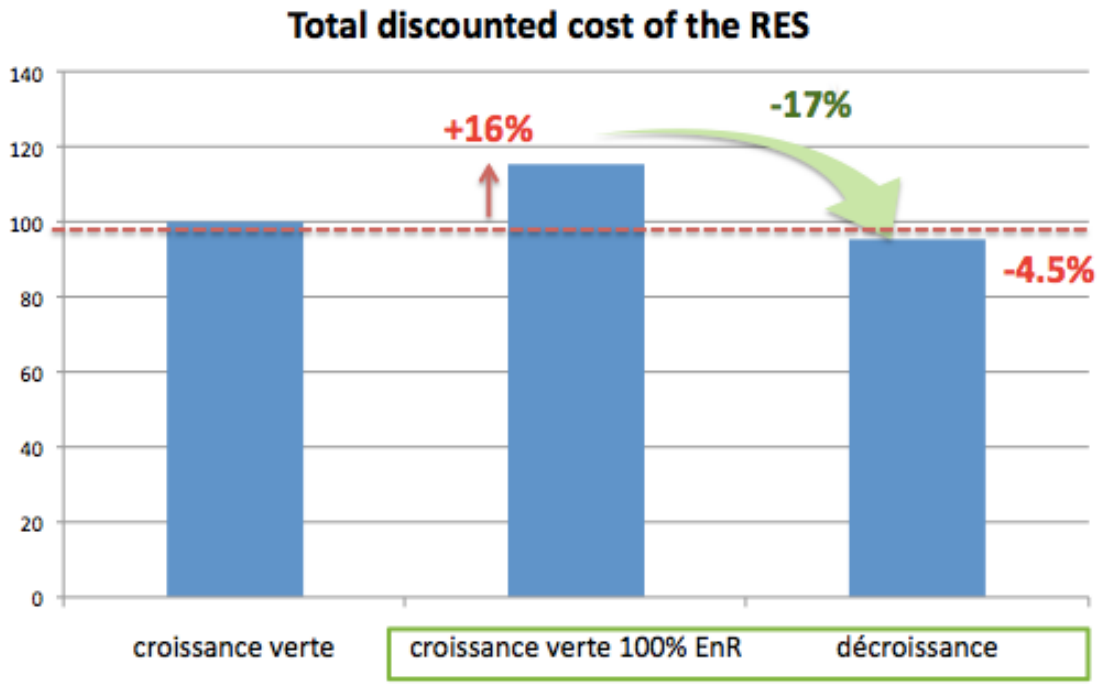
CO_2 emissions of the power system



[F. Briens, PhD thesis, Dec 2015]

Discounted cost of the power system

This questions the discussion about climate change financing.



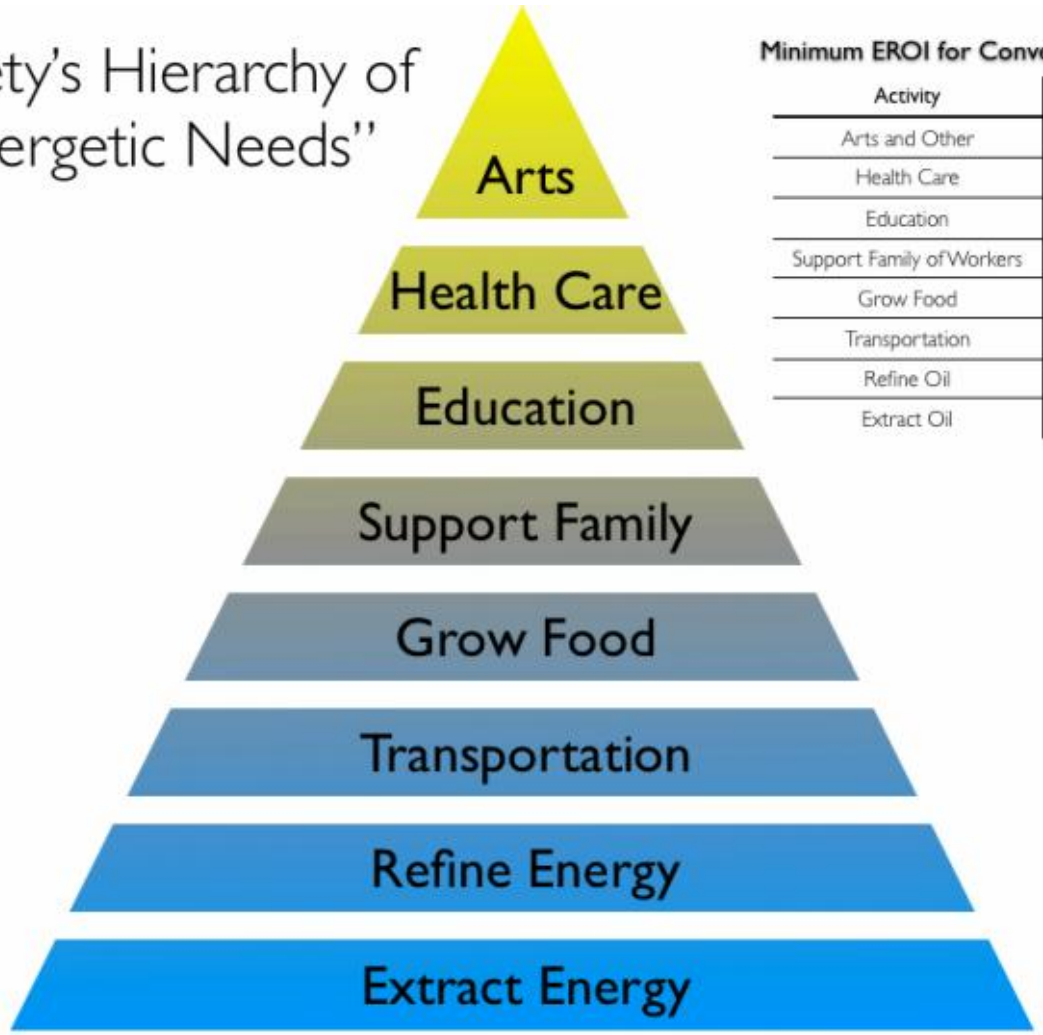
A powerful tool for collective understanding and deliberation

Good potential of Degrowth pathways? but not there yet!

[F. Briens, PhD thesis, Dec 2015]

A degrowth society and EROI concept

What is the avaibility of the pyramid in a Degrowth society ?



Minimum EROI for Conventional Sweet Crude Oil

Activity	Minimum EROI Required
Arts and Other	14 : 1
Health Care	12 : 1
Education	9 or 10 : 1
Support Family of Workers	7 or 8 : 1
Grow Food	5 : 1
Transportation	3 : 1
Refine Oil	1.2 : 1
Extract Oil	1.1 : 1

Conclusive remarks

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Bottom-up long-term investment planning model

enable to identify long-term strategies relevant to all types of climate constraints (e.g. climate-related, financial, legal, political, technical)

- tackle **complex systems** associated more specifically with climate-related issues (technologies, carbon, energy, water, rarefaction of primary resources and functional materials);
- investigate the maturity of **electricity and carbon markets**;
- deal with the challenges of **deploying electrical systems** that integrate technologies linked to renewable energies and smart grids;
- and consider the **central role of people** for whom the future must be acceptable and desirable, i.e. compatible with aspirations and behaviours.

Prospective exercises

based on a methodology

- enabling the evaluation of the quality of service provided to the user
- measuring marginal cost of abatements
- integrating externalities
- assessing sectorial competitions
- dealing with the role of people

is the Condition of the elaboration of the desirable energy transition (the one we wish to elaborate)

either wise **ALL** transitions are possible.

Travaillons donc à bien penser, c'est le principe de la politique. Pascal

More on ....

http://www.modelisation-prospective.org/en

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