ParisTech's Chair Modeling for sustainable development

Planning tools in the climate debate and business opportunities

Nadia Maïzi
S. Bouckaert M. Drouineau E. Assoumou et al.

MINES ParisTech and Chair Modeling for Sustainable Development

COP17 Joint Side Event organized by ICC and ParisTech Chair

Long-term prospective of business contribution to low carbon development

Prospective versus Prediction

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**

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

Prospective versus Prediction

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**

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

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

The TIMES model

A technical linear optimization model driven by demand achieving **a technico-economic optimum**

1. for the **reference energy system** (RES)
2. submit to a set of relevant technical and environmental constraints
3. over a **definite horizon** : long-term (50 years)

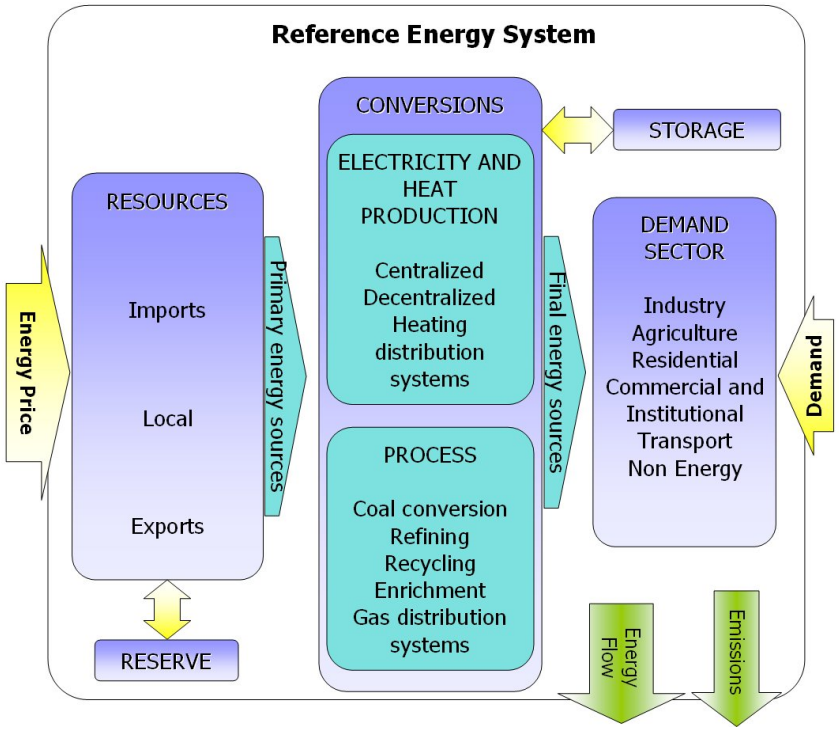


Figure: Reference Energy System

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

ParisTech's Chair Modeling for sustainable development

Competitions, substitutions and technical issues

A technological energy-sector model:

TIMES based on a MARKet ALlocation

- **a highly detailed technological representation**
  for existing and future technologies enabling:
  - a complete description of consumption trends,
  - a precise analysis of substitutions between types of energy,
  - an interpretation of the notion of energy needs in terms of services and equipments,
  - a better evaluation of renewable energy sources.
- an **open-source** model developed in the framework of **ETSAP**:
  Energy Technology Systems Analysis Program initiated by the IEA (in 1980)

Stakes for the energy engineering community and companies

Energy planning modelling approach through TIMES handle issues such as :

- **future investments** for the mix?
- **measures** for the environmental impact?
- what **susbtitution** between energies?

☞ and the community might question the implementation **relevance** and **plausibility** of the energy mix assessed ?

Future power mix issues

ParisTech's Chair Modeling for sustainable development

Future power mix : a major issue for the next decades

- Huge investments are forecasted in the power sector ▸ Jump to IEA prediction.
- Electricity environmental impact are consequent: power generation stands for more than 45% of Carbon Dioxide emissions.

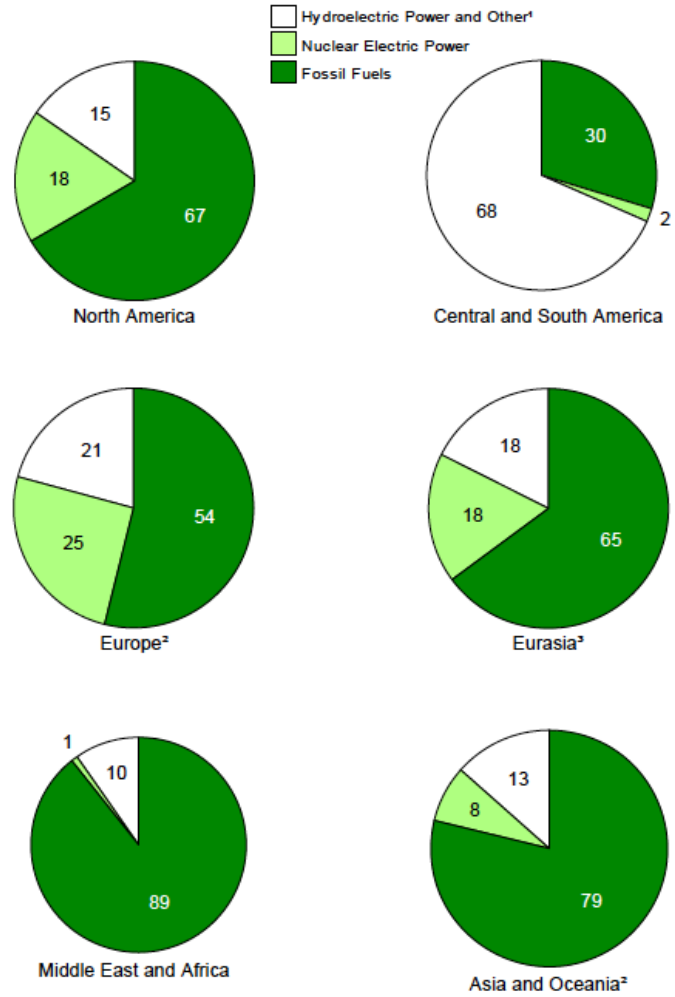


Figure: Power generation by region Source: AER 2009.

Future Power System : generation mix

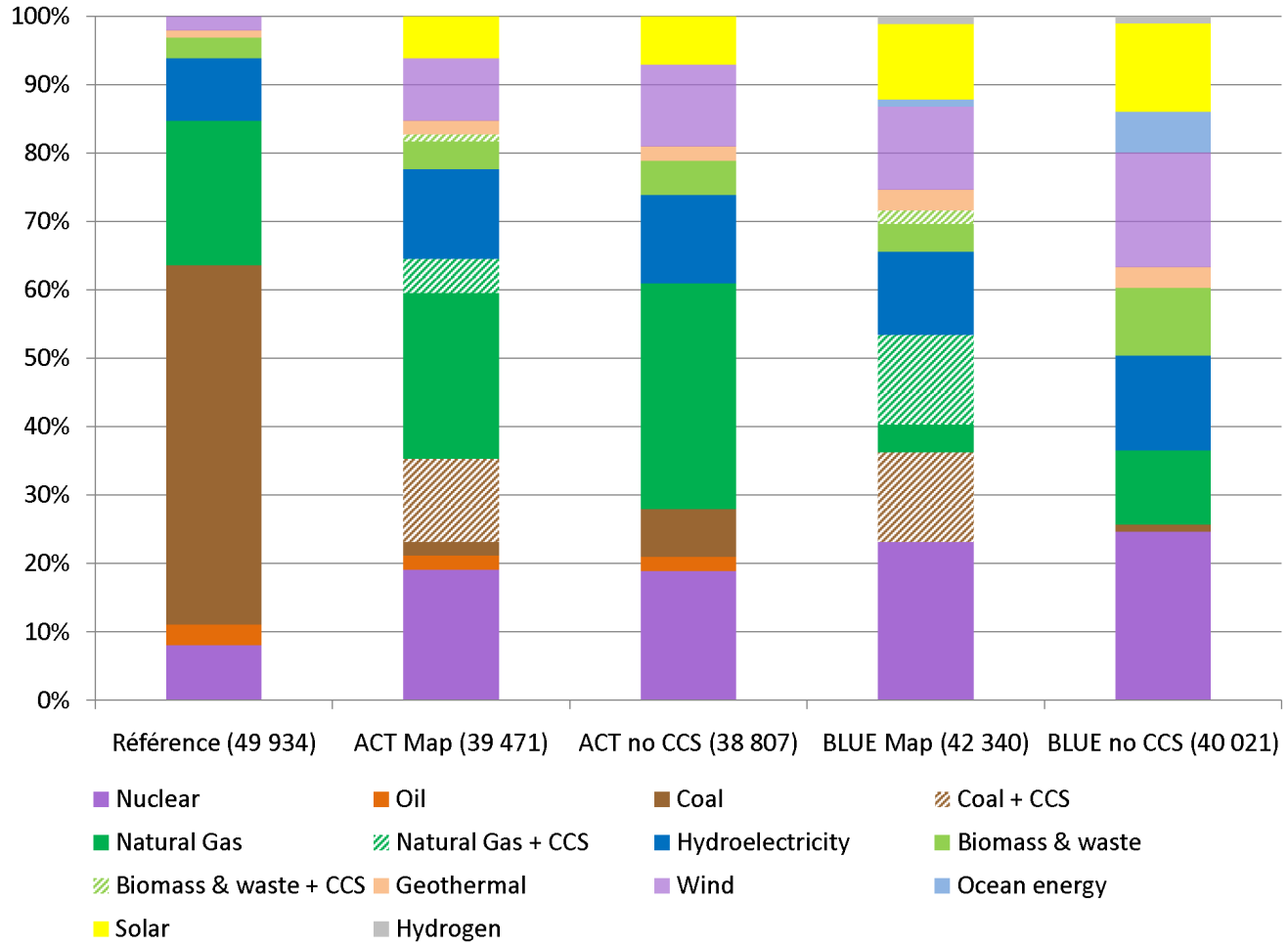


Figure: ETP 2008

Future Power System : network issues

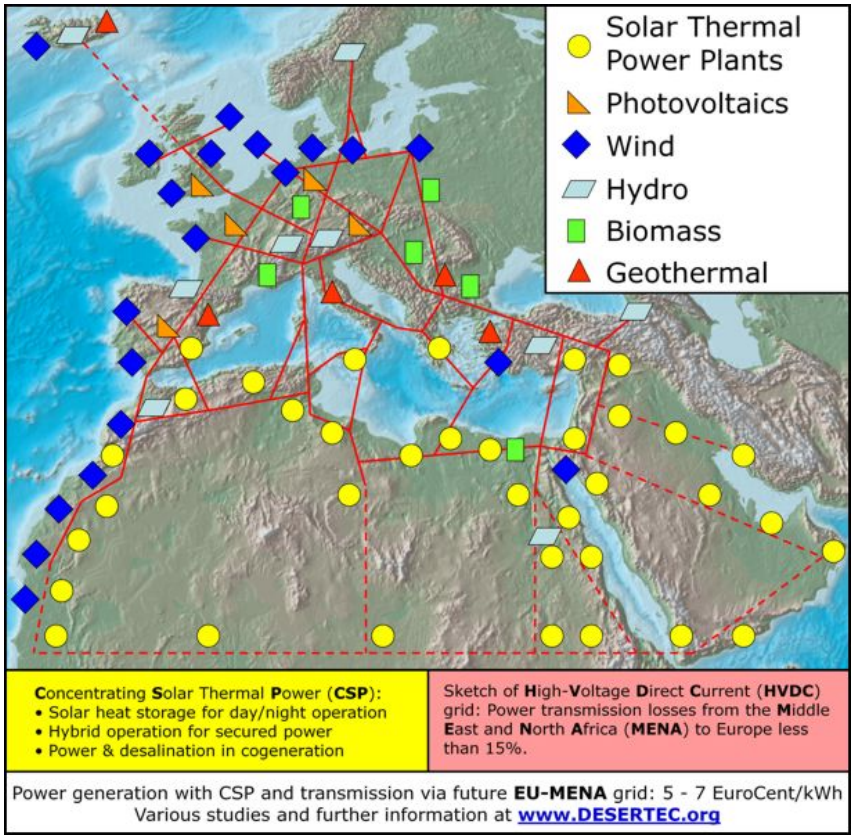


Figure: All-Renewable Electricity Generation in 2050.Source: DESERTEC.

Major Technical and Economics challenges

☞ Renewable and distributed energy sources are attractive alternatives for power generation

1. Water Issues.
2. Intermittency issues.

Future Power System : network issues

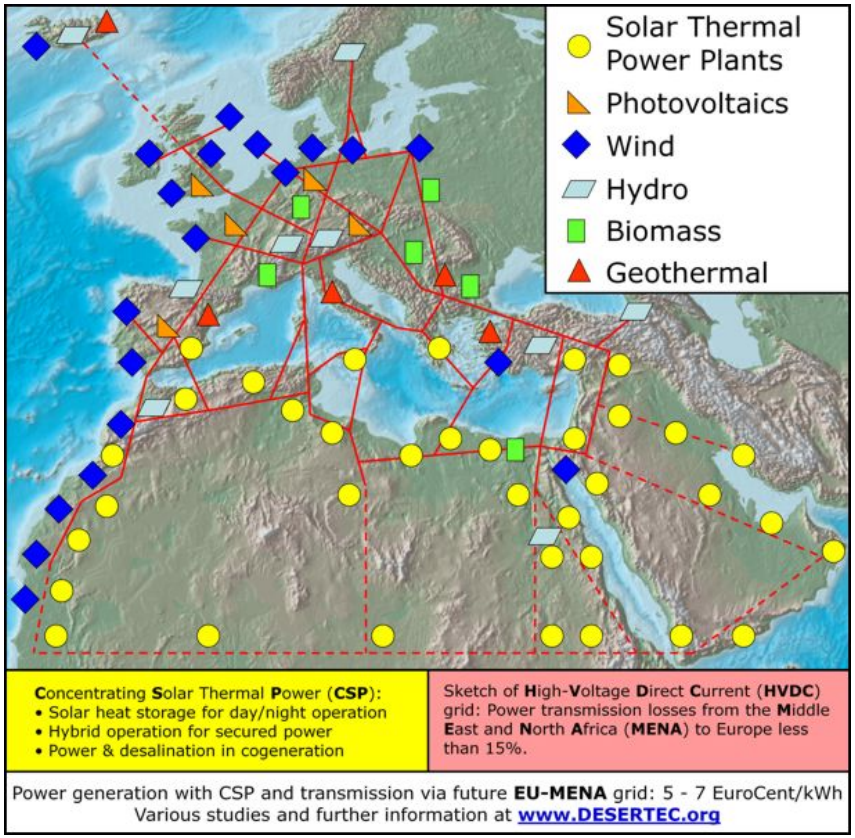


Figure: All-Renewable Electricity Generation in 2050.Source: DESERTEC.

Major Technical and Economics challenges

☞ Renewable and distributed energy sources are attractive alternatives for power generation

1. **Water Issues.**
2. **Intermittency** issues.

Water impacts of power generation

ParisTech's Chair Modeling for sustainable development

Policies dealt separetely but... interdependecy

Growing issues for water and energy

- Energy sector: depletion of fossil resources, environmental impacts
- Water supply: availability and sustainability of water resources

Policies dealt separetely but... interdependecy

Growing issues for water and energy

- Energy sector: depletion of fossil resources, environmental impacts
- Water supply: availability and sustainability of water resources

Water for energy

- Cooling systems
- Hydropower
- Extraction and mining
- Fuel production
- Emission controls

Energy for water

- Pumping
- Transport
- Treatment
- Desalination

Water impact of the assessed Power mix

In order to analyze the influence on water of the assessed power mix

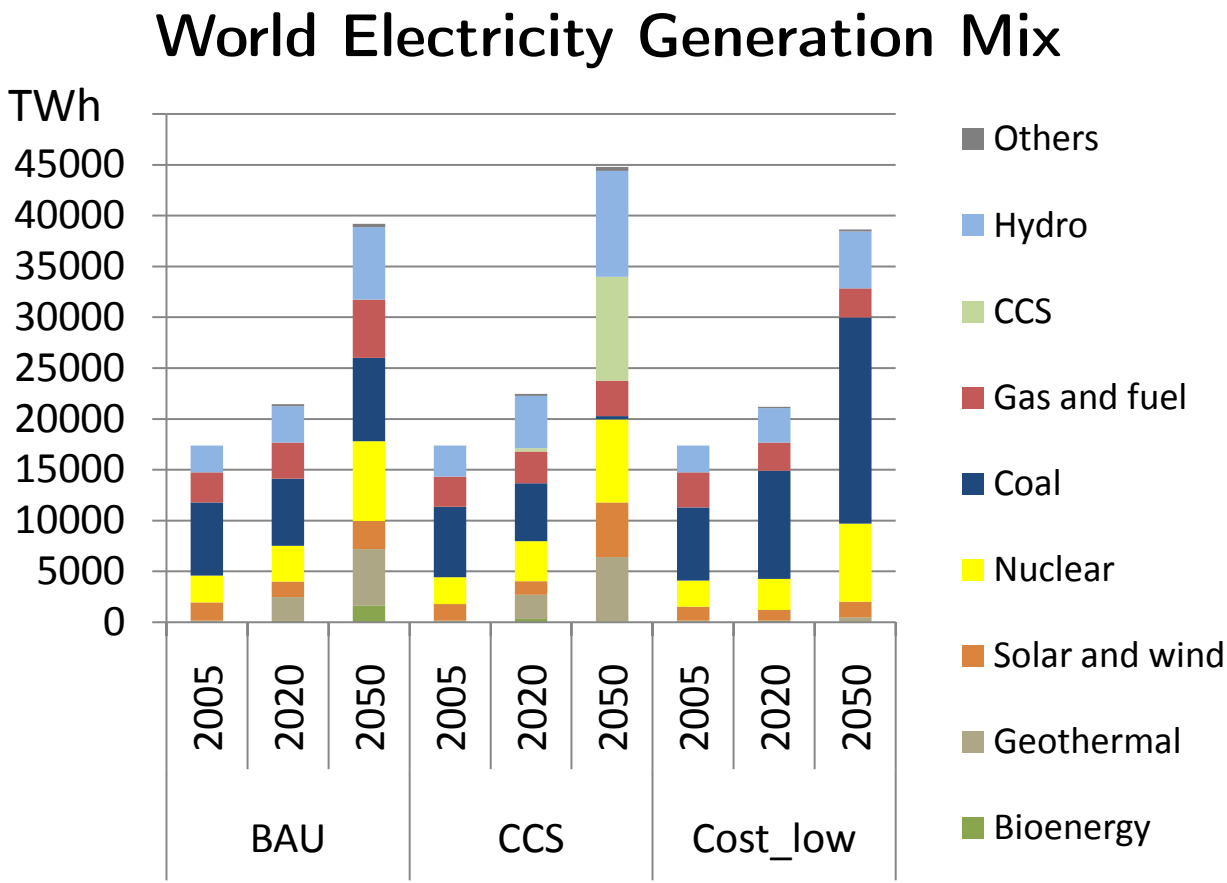
we consider scenarios reflecting

1. Environmental policies and extraction costs
2. Water as a constraint

where Water factor for each technology mainly depends on :

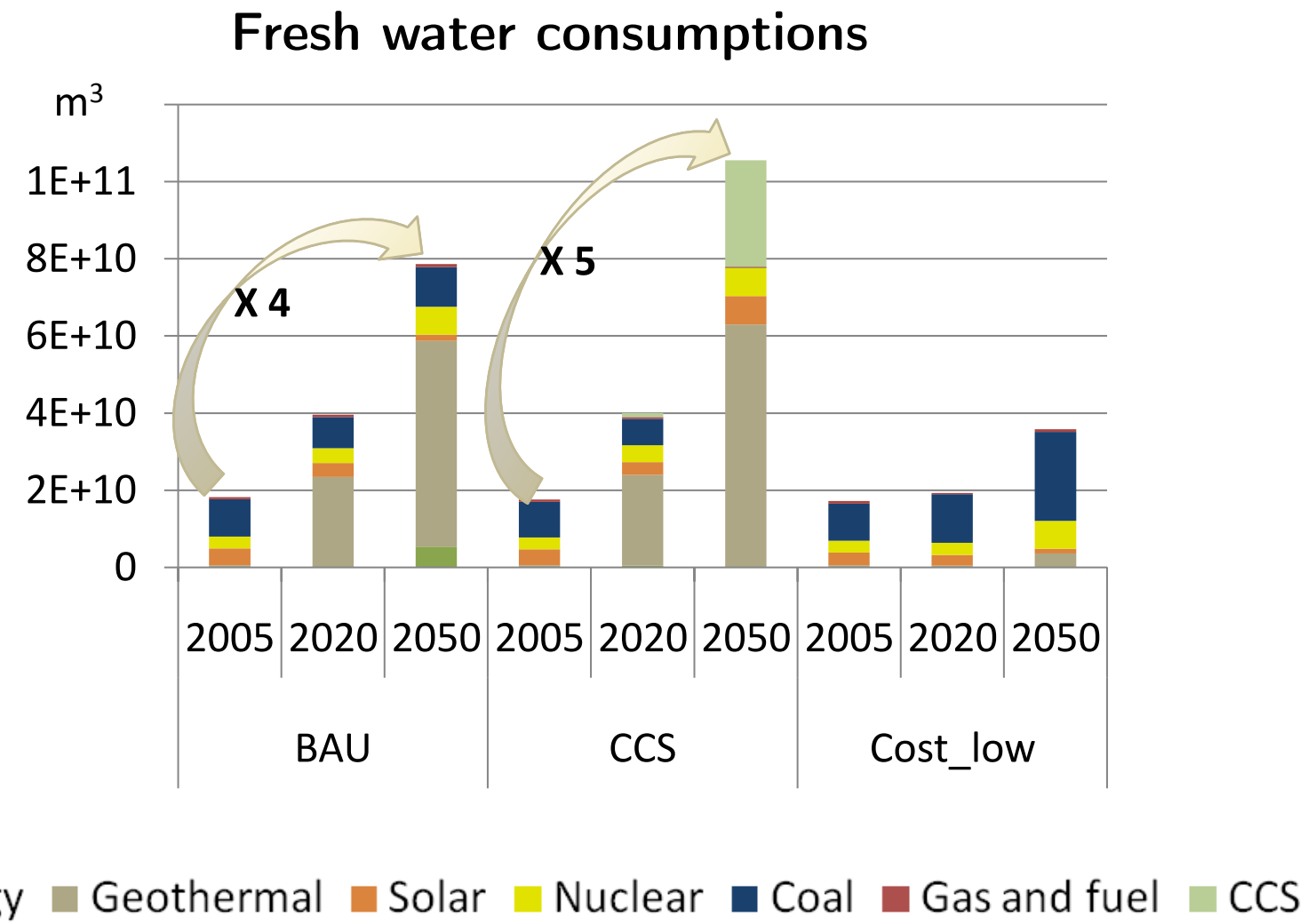
- *Upstream*: type of coal mine, ratio onshore/offshore etc.
- *Electricity*: cooling systems, efficiency, FGD etc.

Environmental policies and decrease of extraction costs

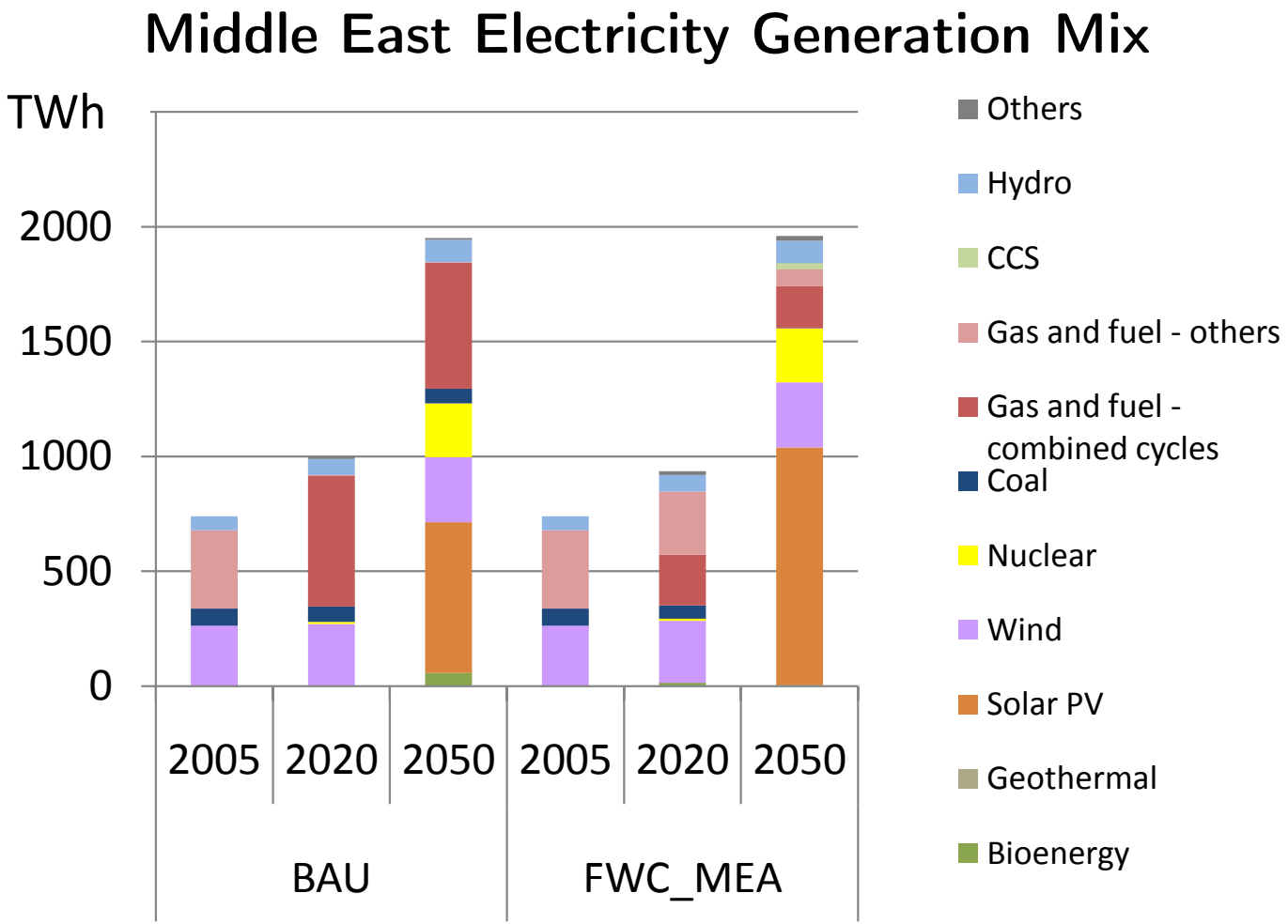


- CCS : constraint the energy system to a maximum increase of temperature of 2°C in 2100
- Cost_low : decrease of extraction cost of fossil energy

Environmental policies and decrease of extraction costs



Water as a constraint



- FWC_MEA: fresh water consumptions in Middle East until 2100 $\leqslant$ consumptions in 2005

Reliability issues

ParisTech's Chair Modeling for sustainable development

Future Power System : Reliability of electricity supply

Figure: Europe from orbit during the Italian blackout (Sept. 28th, 2003). Source: French TSO.

Technical constraints binding the operation of the future power system are related to:

- the given level and spatial distribution of loads and capacities;
- the expected level of reliability to prevent from power outages.

☞ Where **reliability** is the capability of the power system to withstand sudden disturbances due to load fluctuations.

Future Power System : Reliability of electricity supply

Figure: Europe from orbit during the Italian blackout (Sept. 28th, 2003). Source: French TSO.

Technical constraints binding the operation of the future power system are related to:

- the given level and spatial distribution of loads and capacities;
- the expected level of reliability to prevent from power outages.

☞ Where **reliability** is the capability of the power system to withstand sudden disturbances due to load fluctuations.

Assesing future power systems : dynamics issues

Stability studies

involve time scales ranging from a few milliseconds to a few hours

Long-term planning models

deal with several years or decades

The level of reliability of the power system can be derived from

- the **dynamic properties** of the installed capacities
- the associated inertia of the system (kinetic and magnetic)
- the load profile.

characterized by H :

the time you have to recover the stability of the system after a load fluctuation by monitoring its reserves.

Assesing future power systems : dynamics issues

Stability studies

involve time scales ranging from a few milliseconds to a few hours

Long-term planning models

deal with several years or decades

The level of reliability of the power system can be derived from

- the **dynamic properties** of the installed capacities
- the associated inertia of the system (kinetic and magnetic)
- the load profile.

characterized by H :

the time you have to recover the stability of the system after a load fluctuation by monitoring its reserves.

Assesing future power systems : dynamics issues

Stability studies

involve time scales ranging from a few milliseconds to a few hours

Long-term planning models

deal with several years or decades

The level of reliability of the power system can be derived from

- the **dynamic properties** of the installed capacities
- the associated inertia of the system (kinetic and magnetic)
- the load profile.

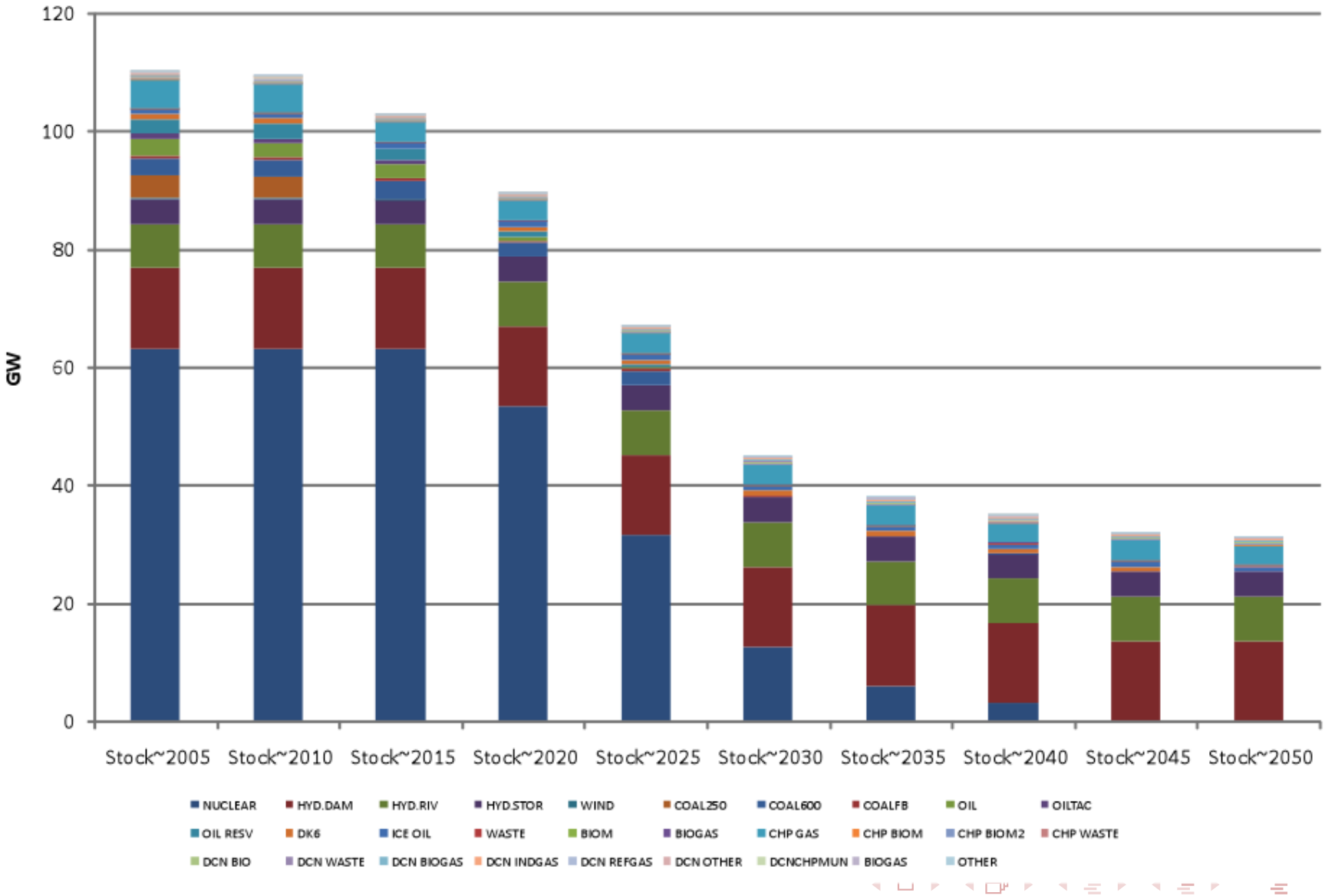
characterized by H :

the time you have to recover the stability of the system after a load fluctuation by monitoring its reserves.

French electricity paradigm

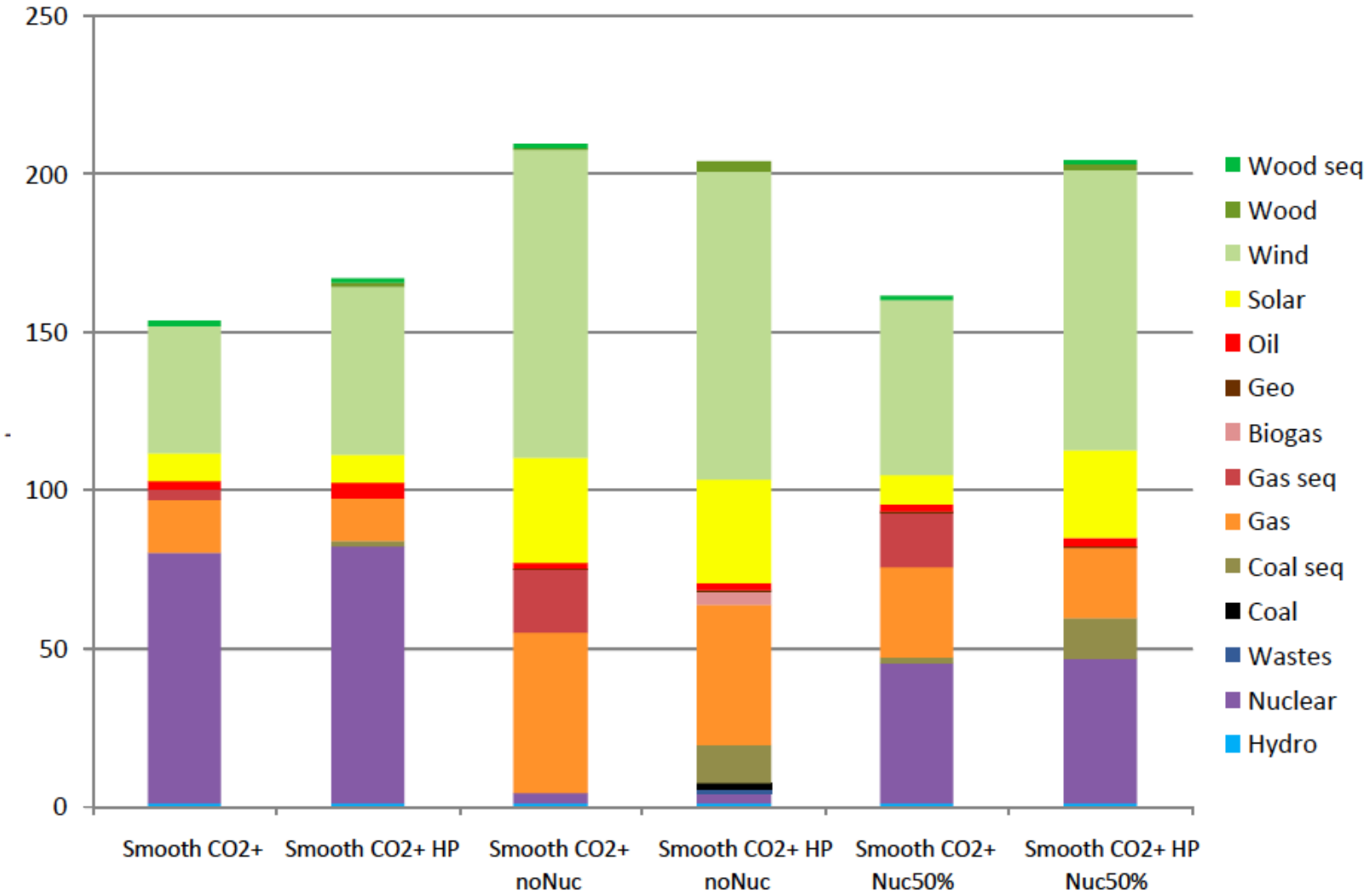
ParisTech's Chair Modeling for sustainable development

Nuclear power replacement is the main driver for the future

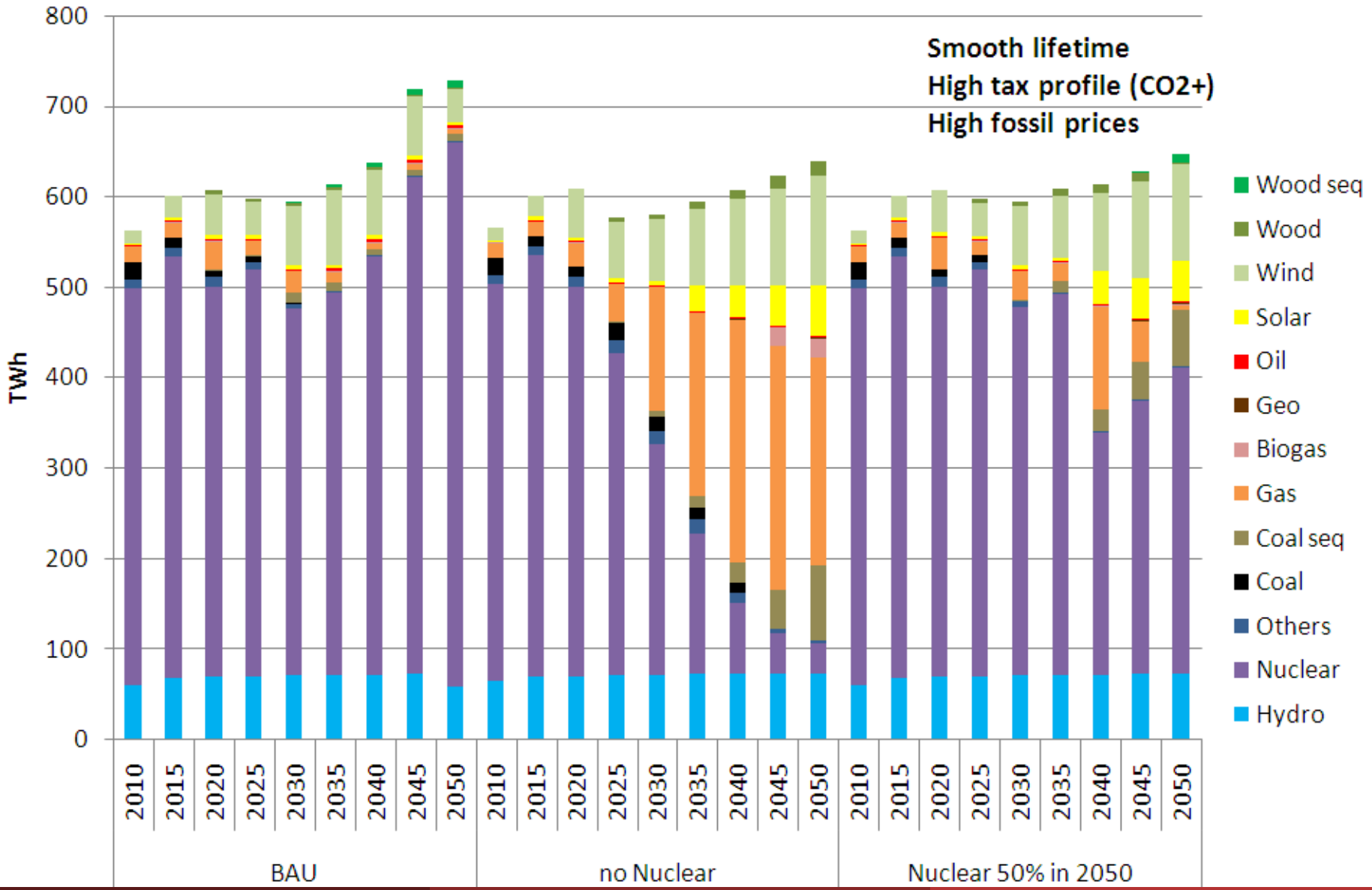


Huge investments are needed

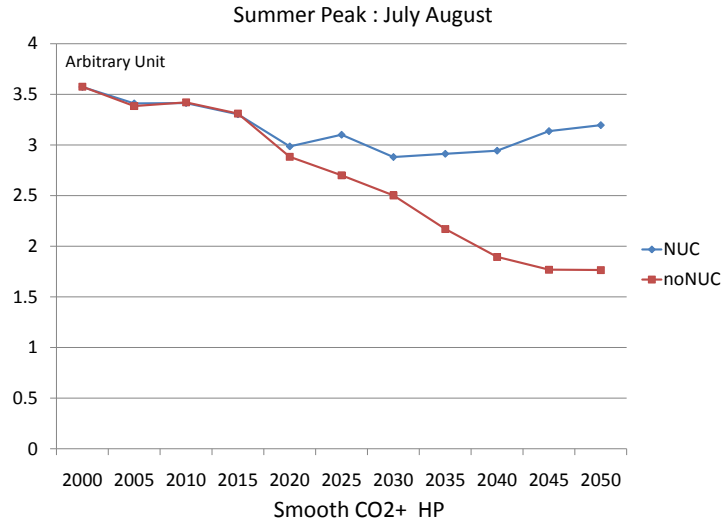
☞ new generation capacities to secure power supply

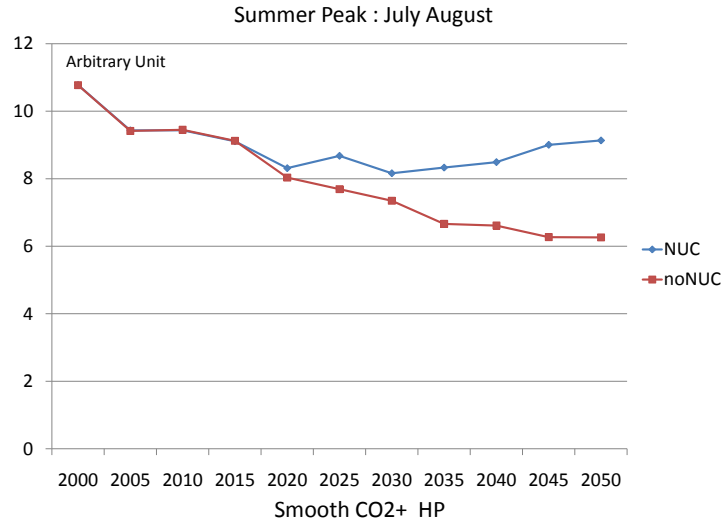


Fossil price and CO_2 tax sensitivity : High Prices, High Tax

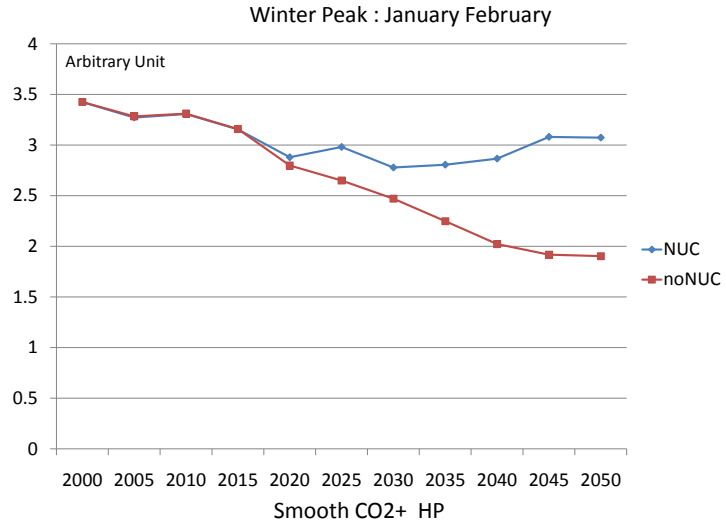


Reliability robustness of the power mix : nuclear sensitivity

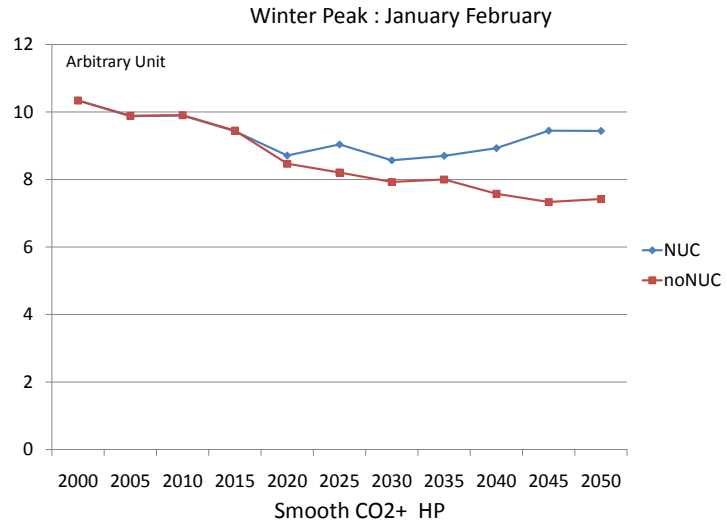




Kinetic reserves



Magnetic reserves



Technical plausibility of power generation assessed scenarios

In order to cope with environmental issues, some technological options are highly recommended.

Strategic factors impact technical feasibility and relevance of future power mix

1. **Water** as an output commodity and as a constraint
2. **Level of reliability** of an assessed power mix system

Prospective issues have been raised using planning tools : the power mixes must fulfill a balance :

a global optimum associating water and energy

between reliability issue and the spread of renewable energies

Technical plausibility of power generation assessed scenarios

In order to cope with environmental issues, some technological options are highly recommended.

Strategic factors impact technical feasibility and relevance of future power mix

1. **Water** as an output commodity and as a constraint
2. **Level of reliability** of an assessed power mix system

Prospective issues have been raised using planning tools : the power mixes must fulfill a balance :

a global optimum associating water and energy

between reliability issue and the spread of renewable energies

Contact
nadia.maizi@mines-paristech.fr

Web Site
http://www.modelisation-prospective.org/index_en.html

ParisTech's Chair Modeling for sustainable development