



Households under Carbon Constraint and the Burden Sharing Issue

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CONTEXT

- Well-known context : fossil fuels depletion, climate change & security of supply
- French & European political context : 2020 & Factor 4: 50-75% reduction by 2050
 - **Strong carbon constraint**

Issues

- What are the least cost solutions of energy saving ? How to reach F4 constraint ?
- How does this strong carbon constraint would be distributed over households ?
 - **Burden sharing** issue : Efficiency and Equity are not necessarily linked

OUTLINE

1 - Some Insights about Households Energy Consumption

2 - The TIMES Model

3 - French Residential Sector : Space Heating and Water Heating Model

4 - First Results

5 – Conclusion & Perspectives

1 – Some insights about Households Energy Consumption (1/2)

Households energy consumption depends on **3 kinds of drivers**

- Availability of technologies

- Transport networks: subway, trains, bus... (*localization : rural/urban*)
- Building thermal Insulation refurbishment (*occupation status : tenant/landlord*)
- Solar water-heater (*housing type : individual/collective*)

- Initial level of demand

- *Level of home thermal insulation* (for space heating needs)
- *Efficiency and age of equipments* (boiler, car, water-heater...)
- *Home size*
- *Household size* (mobility, hot water)
- *Status of household's members* : worker, student, retired... (mobility)
- *Localization* (distance to amenities: shops, schools, services, stadiums...)

1 – Some insights about Households Energy Consumption (2/2)

- **Household's behaviour**

- Way to purchase equipments: Choice criteria between equipment's attributes (cost, confort, safety, simplicity...), capital constraints:
Income, age, culture, presence of children

- **Influences apparent discount rate**

- Way to consume energy: Compromises between cost and confort, habits, information
Income, age, presence of children, education, values, attitudes, social norms...

- **Influences price-elasticity of energy service**

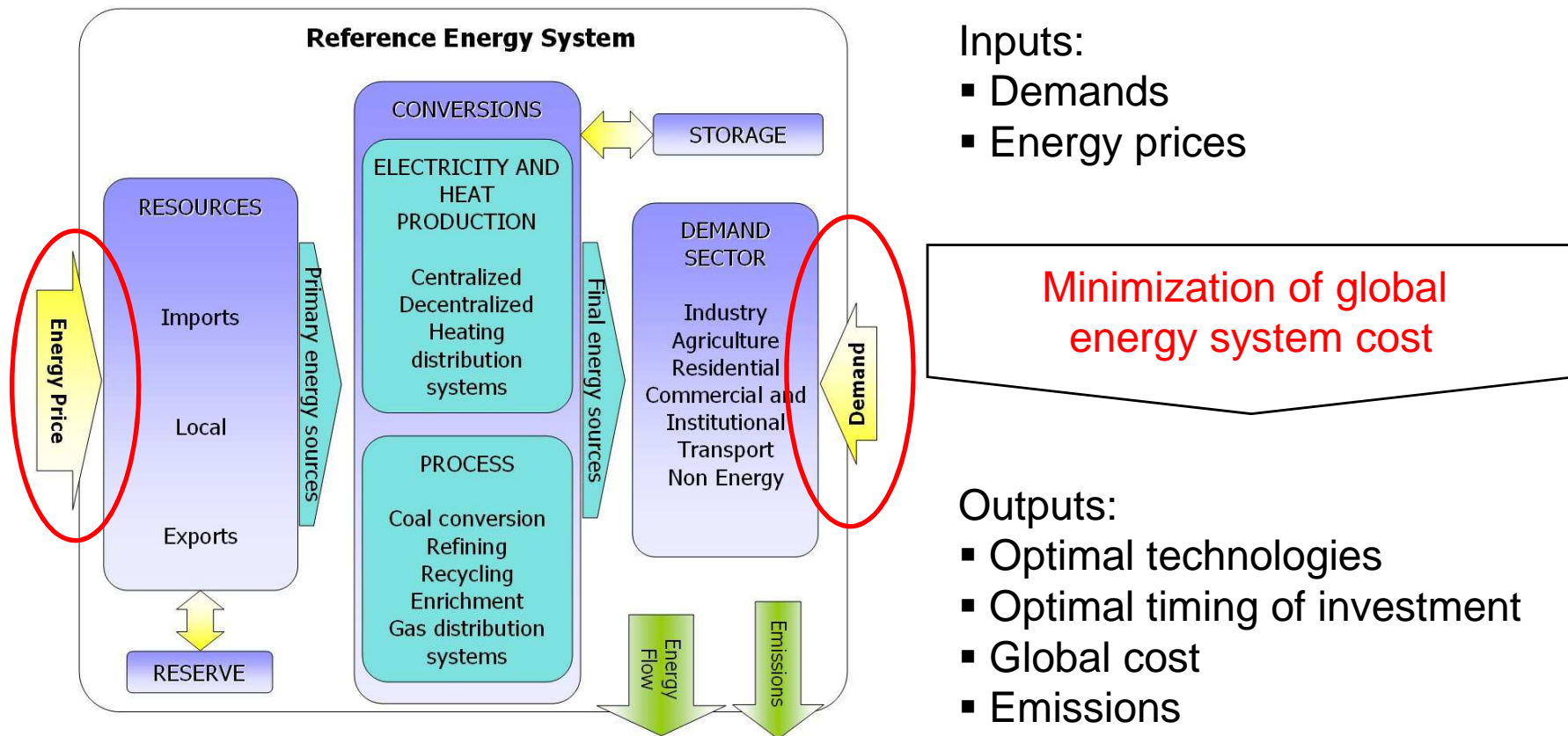
- Household's behaviour is linked to the notion of **way of life** and is quite **homogeneous** in a socio-demographic category

- All of these 3 kinds of drivers **strongly vary** with household's characteristics and are **partly correlated**

 Necessity to consider **segments of households** in models

2 – The TIMES Model (1/2)

- TIMES is an **optimization**, technological-oriented, **bottom-up**, long-term planification tool



2 – The TIMES Model (2/2)

Some limits of the TIMES approach:

- **No macroeconomic** feedback : demands and prices are exogenous and independant.
- Quite basic microeconomic principle: **optimization** with **perfect foresight** on future energy prices
→ Both are unrealistic to describe households behaviour

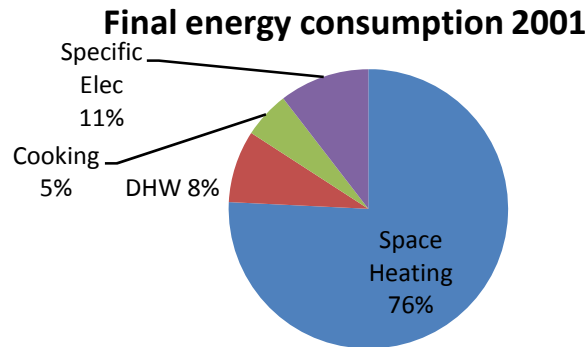
But

- **Apparent discount rates** and **Price-Elasticities** can be used to represent a more realistic behaviour and link demands to prices
- TIMES can easily estimate **sensibility** to key-parameters
- Necessity to proceed with segments : **Bottom-up** model
- TIMES model provides insights about **least cost** energy/carbon saving solutions

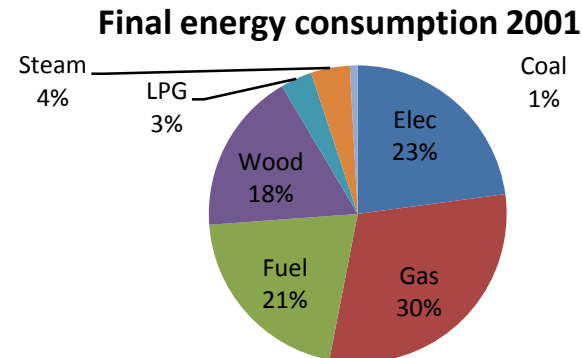
→ TIMES is not a simulation tool, it gives a normative approach

3 – Residential sector: Space heating & Water heating model (1/4)

- French Residential sector consumes 556 TWh in 2001



Source: CEREN 2002

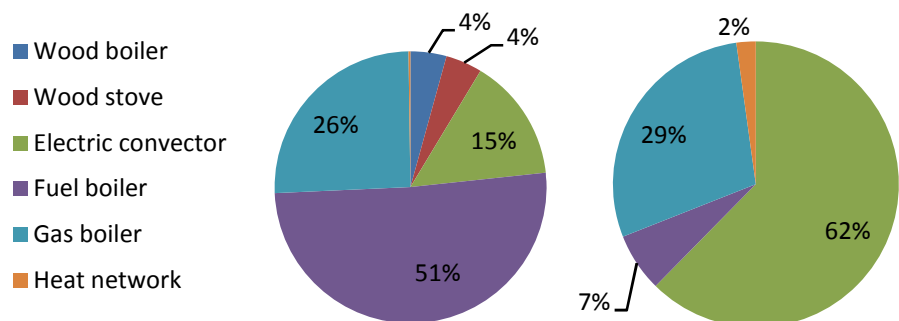


Source: CEREN 2002

- High heterogeneity** between dwellings in total consumption & market shares

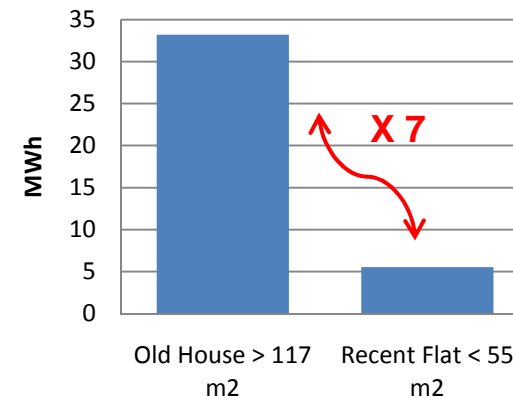
Old House > 117m2

Recent Flat < 55m2

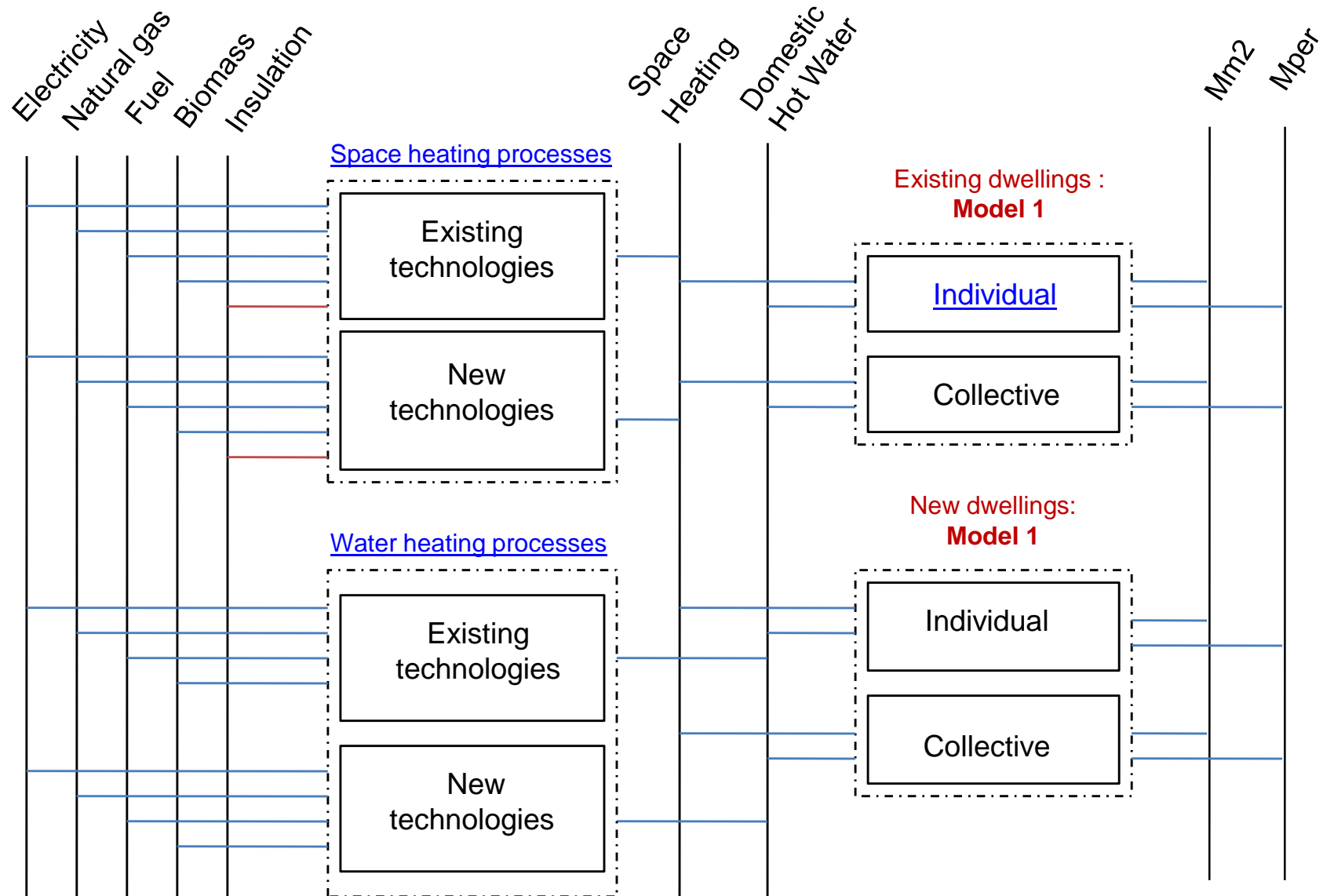


Source: INSEE 2002

Space Heating consumption



3 – Residential sector: Space heating & Water heating model (2/4)



3 – Residential sector: Space heating & Water heating model (3/4)

Summary of the 3 models

- Construction year is linked to building thermal insulation level
- Discount rate is linked to household's level of income/capita

Type of Driver	Attribute	Level of disaggregation	Model 1	Model 2	Model 3
Availability of technologies	Housing Type	Individual / Collective	X	X	X
Initial level of demand	Construction Year	Before 1949 / 1949-1975/ 1975-1990 / After 1990		X	X
	Housing Size	Ind: < 55m ² / 55-75m ² / >75m ² Coll: < 90m ² / 90-117m ² / >117m ²		X	X
Household's behaviour	Discount Rate	Low: 5% / Medium: 8% / High:11%			X
		<i>N° Segments</i>	2	24	72

3 – Residential sector: Space heating & Water heating model (4/4)

- **High** & **Low** fossil energy prices scenarios:

Energy	2014	2019	2029
Crude oil (\$05/bl)	114 / 65	131 / 75	131 / 75
Natural gas (\$05/Mbtu)	14 / 8	19 / 11	19 / 11
Fuel (€/MWh)	122 / 70	141 / 80	141 / 80
Gas (€/MWh)	73 / 51	92 / 62	92 / 62
Electricity (€/MWh)	153 / 125	177 / 139	177 / 139
Biomass (€/MWh)	42 / 42	46 / 46	53 / 53
Steam (€/MWh)	67 / 54	77 / 60	77 / 60

Source: CAS 2005 & EDF R&D 2008

- Price of crude oil barrel : Factor 2 between the 2 scenarios in 2030

4 – Results (1/5) : Impact of model segmentation on technology choice

Attractiveness of an investment:

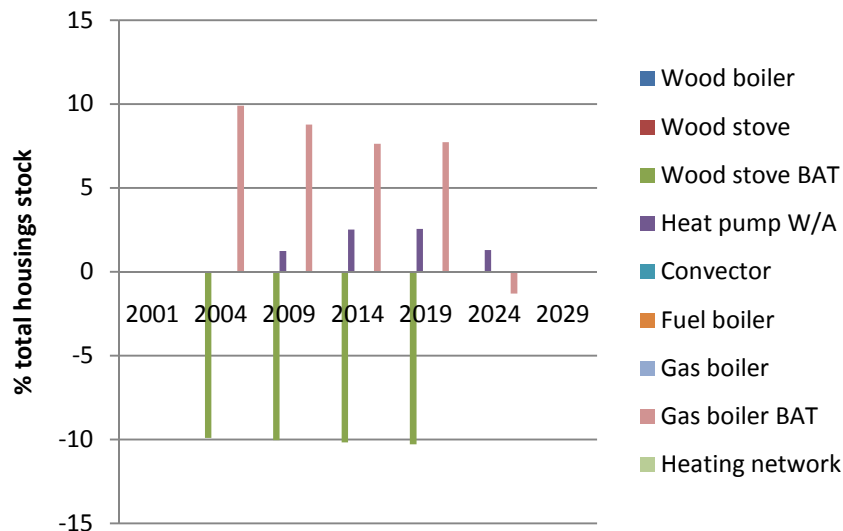
$$NPV = -C_0 + \sum_{i=1}^{LT} \frac{P_i * \Delta kWh_i}{(1+a)^i}$$

C_0, LT Technology attributes
 ΔkWh_i Initial level of demand
 a Discount rate

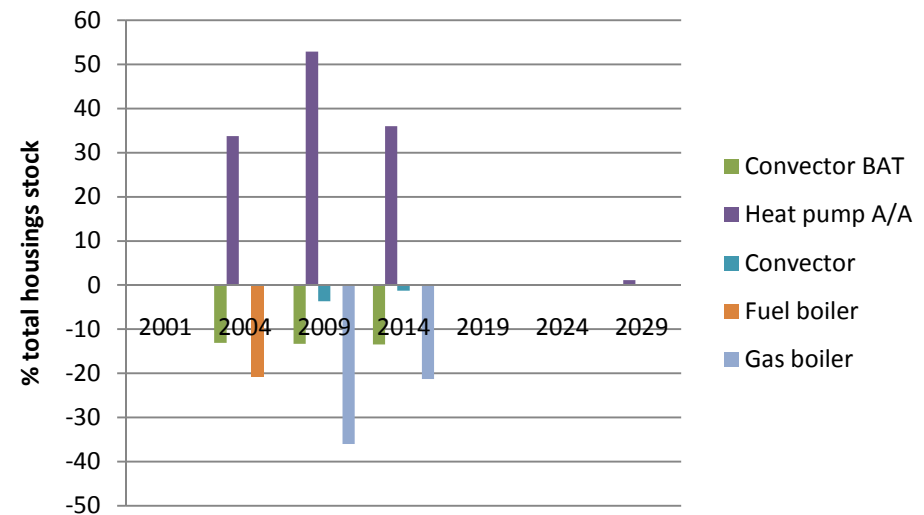
Model 1: **Mean** Individual House (IH)
 Model 2: IH, <1949 (**bad thermal insulation**), >117m²

Model 1: **Mean** Collective Housing (CH)
 Model 2: CH, <1949 (**bad insulation**), >75 m²

Differences between model 2 & model 1: low prices



Differences between model 2 & model 1: high prices

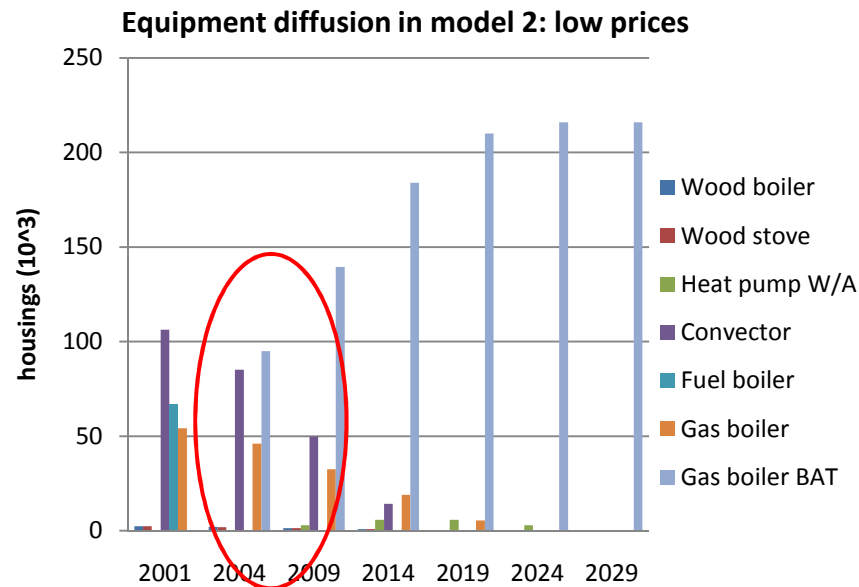


Important changes in technology choice (in % of stock)

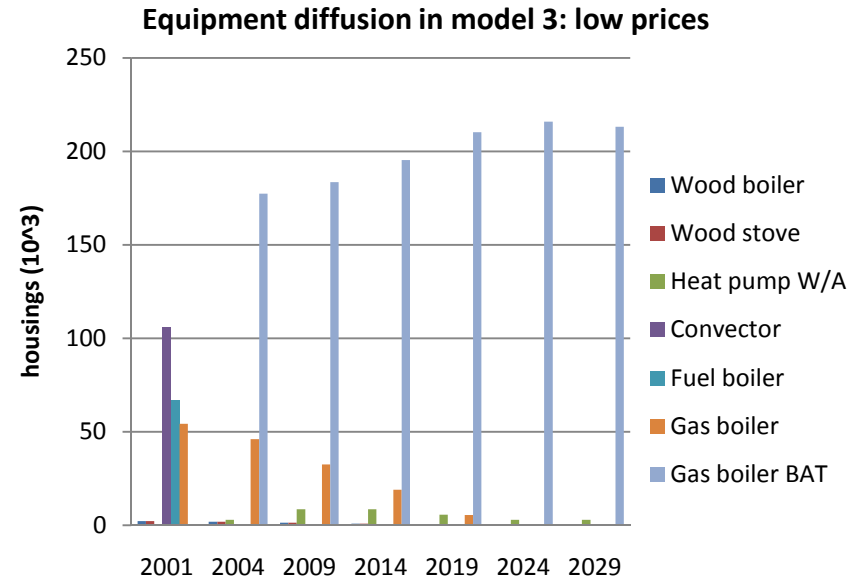
4 – Results (2/5) : Impact of model segmentation on technology choice

Exemple of Segment: IH, 1949-1975 (quite bad insulation), >117 m2

DR = 8%



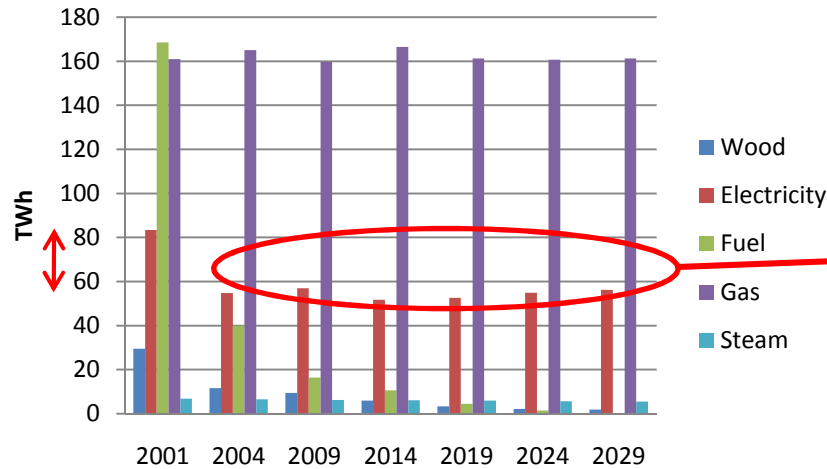
DR = 5%



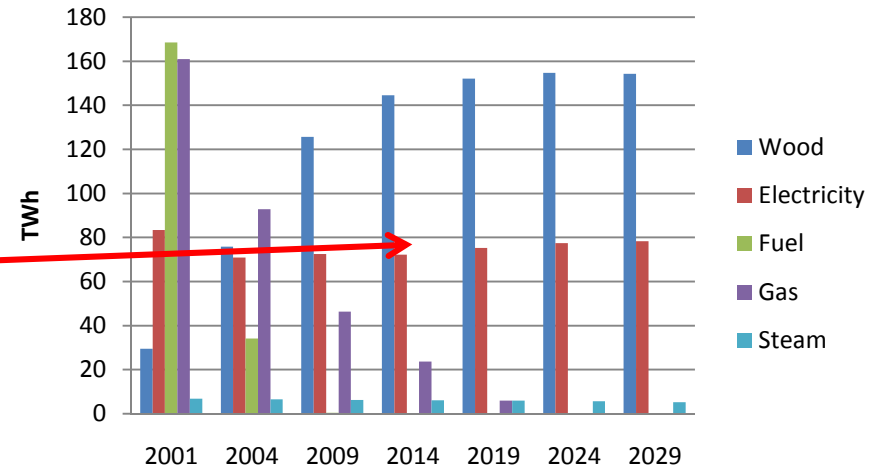
Influences also timing of investments

4 – Results (3/5) : Impact on total Energy Consumption

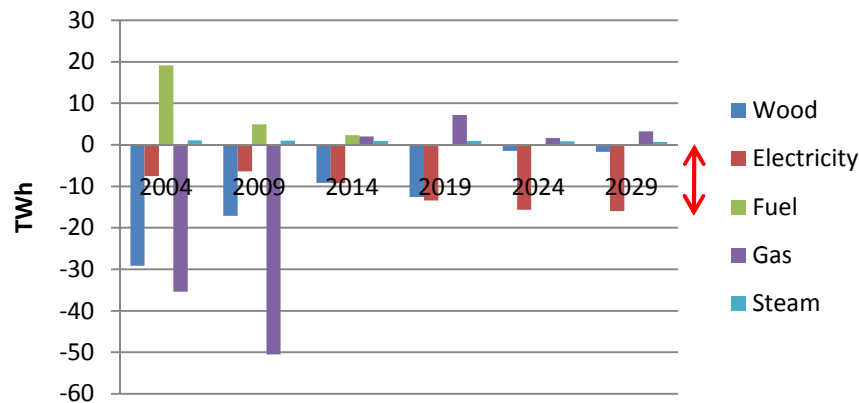
Total energy consumption in model 3: low prices



Total energy consumption in model 3: high prices



Differences between model 3 & model 1: low prices

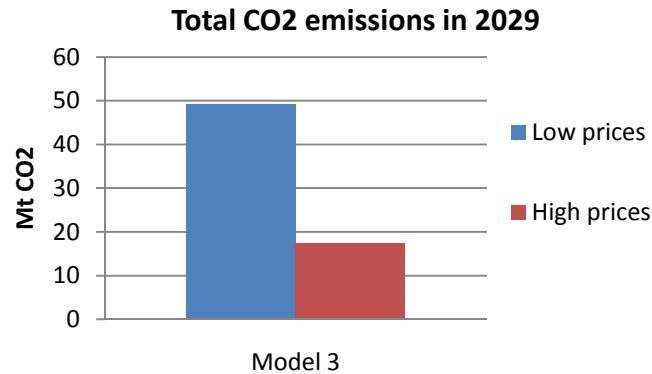


→ Difference in electricity consumption:

- Price scenarios: **20 TWh**
- Model structure: **15 TWh**

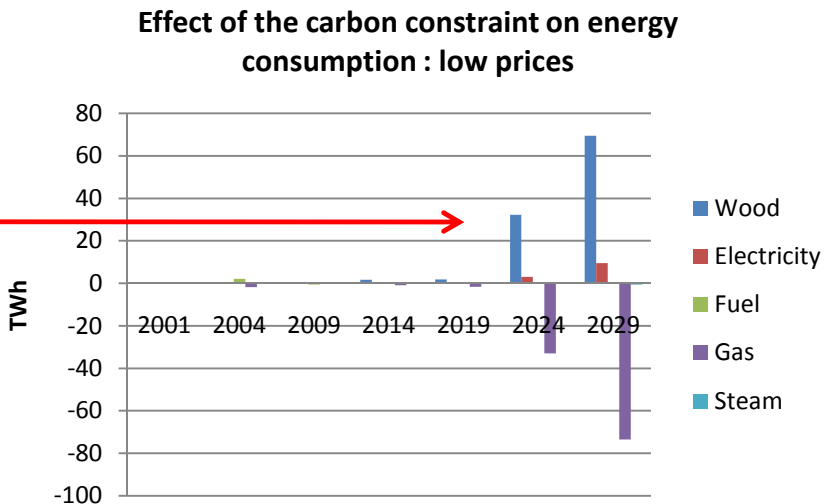
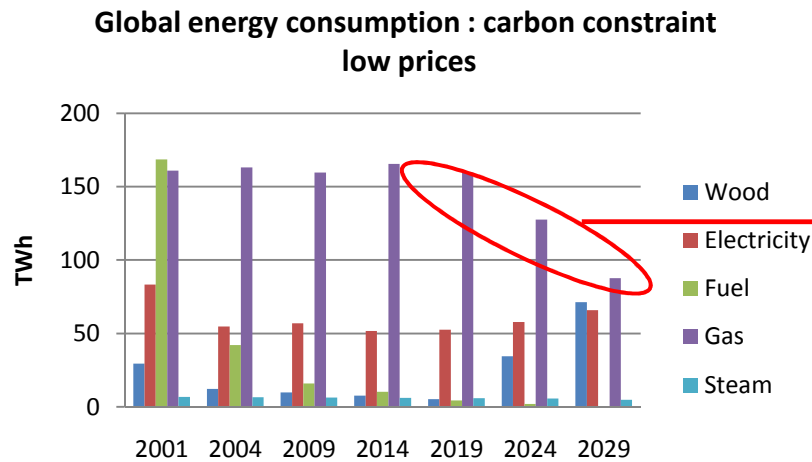
→ Total energy consumption is **highly influenced** by level of segmentation of the households

4 – Results (4/5) : The « Carbon constraint » Scenario



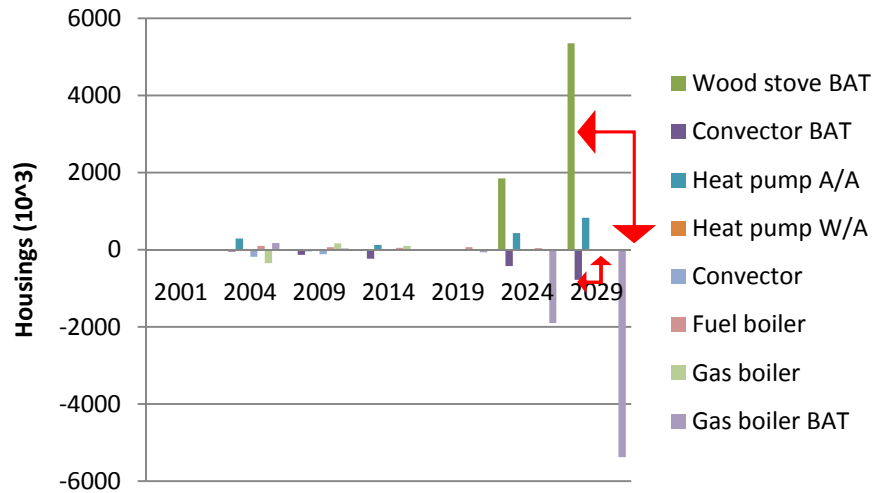
- Low prices → 50Mt CO2 in 2029 (= 1990 level)
- What happened with a « **constraint** » scenario ?

➔ **Carbon constraint: 31Mt CO2 in 2029, coherent with a F4-like path (-30%/1990)**



4 – Results (5/5) : Burden sharing of a global carbon constraint

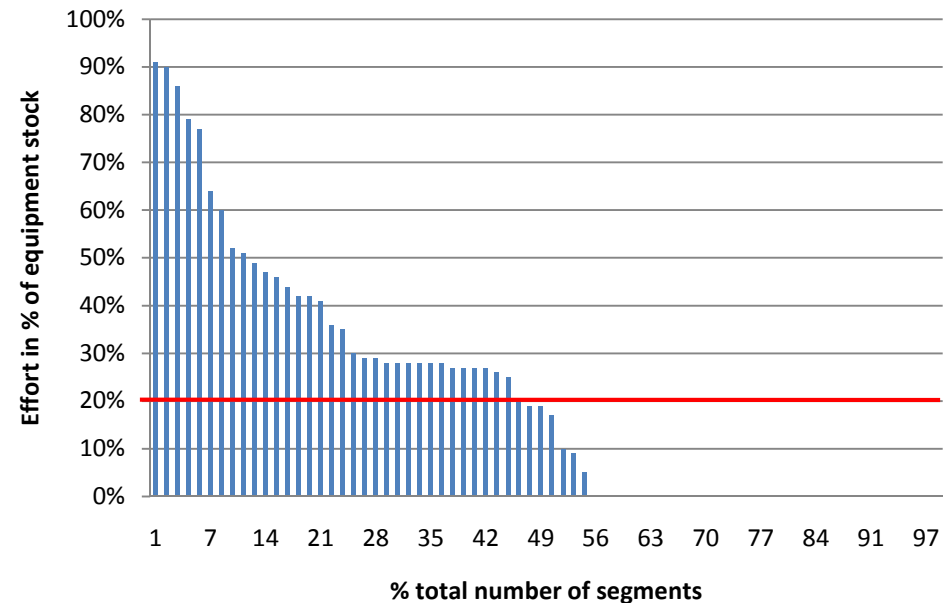
Effect of carbon constraint on technology diffusion:
low prices



- 5 Millions of households are concerned : **20%**
- Houses: Wood stoves instead of Gas boilers
- Flats: Heat Pumps instead of Convectors

- **Strong dissymetry** in efforts between households to satisfy the carbon constraint

Efforts of different segments of households under "carbon constraint"



➡ **TIMES : Which households contribute the most** to the carbon constraint

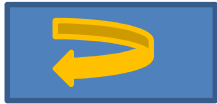
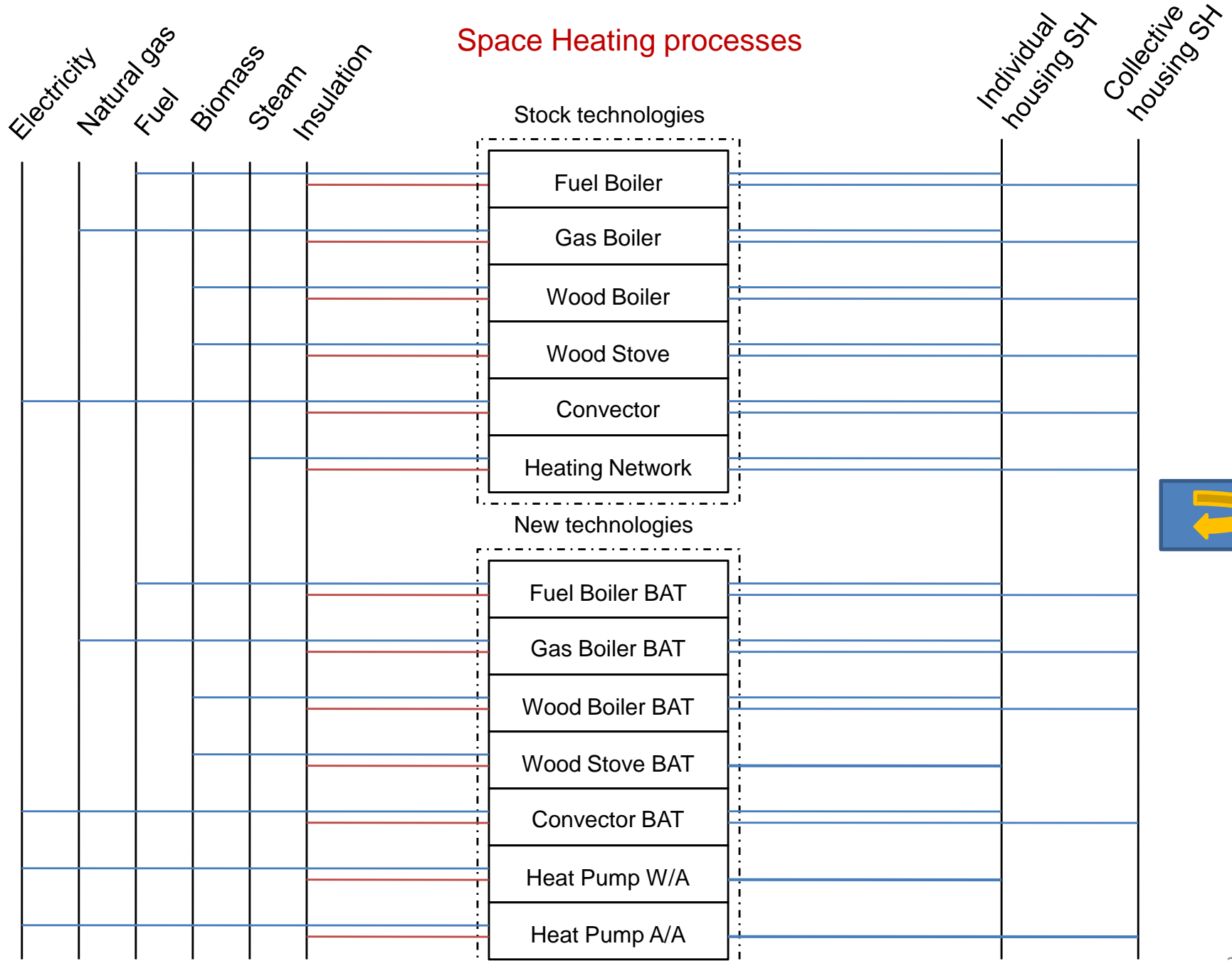
5 – Conclusion & Perspectives

- Main interest is to show the the importance of modelling **segments** of households **instead of mean** household :
 - To compare households under « constraint »
 - To improve realism of global modelling
 - To better understand the impact of policy instruments : taxes, incitations ...
- This first study has been done in a quite coherent context :
values of parameters **near** of those **used in prospective exercises**
- **2000** french households **survey** is launched to get some data:
 - Collect at the **same time residential & transports** energy consumption
 - Better information about housing's insulation
 - Energy **restriction behaviour**
 - **Declarative discount rates** for equipment purchase
 - Individual characteristics: preferences, attitudes, values...

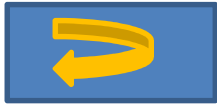
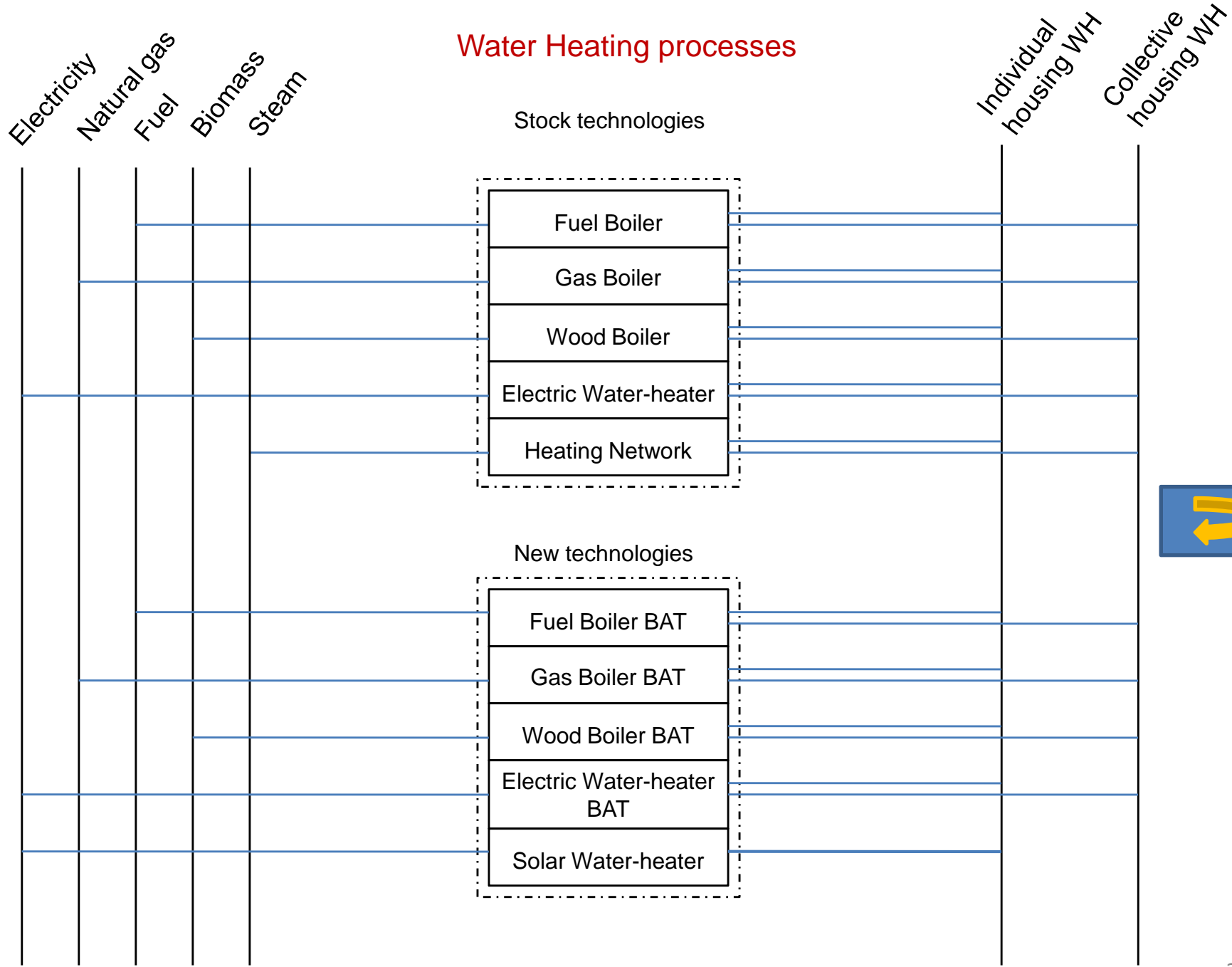
 Improve the segmentation of french households (Residential & Transports)

Thank you for
your Attention !

Space Heating processes



Water Heating processes



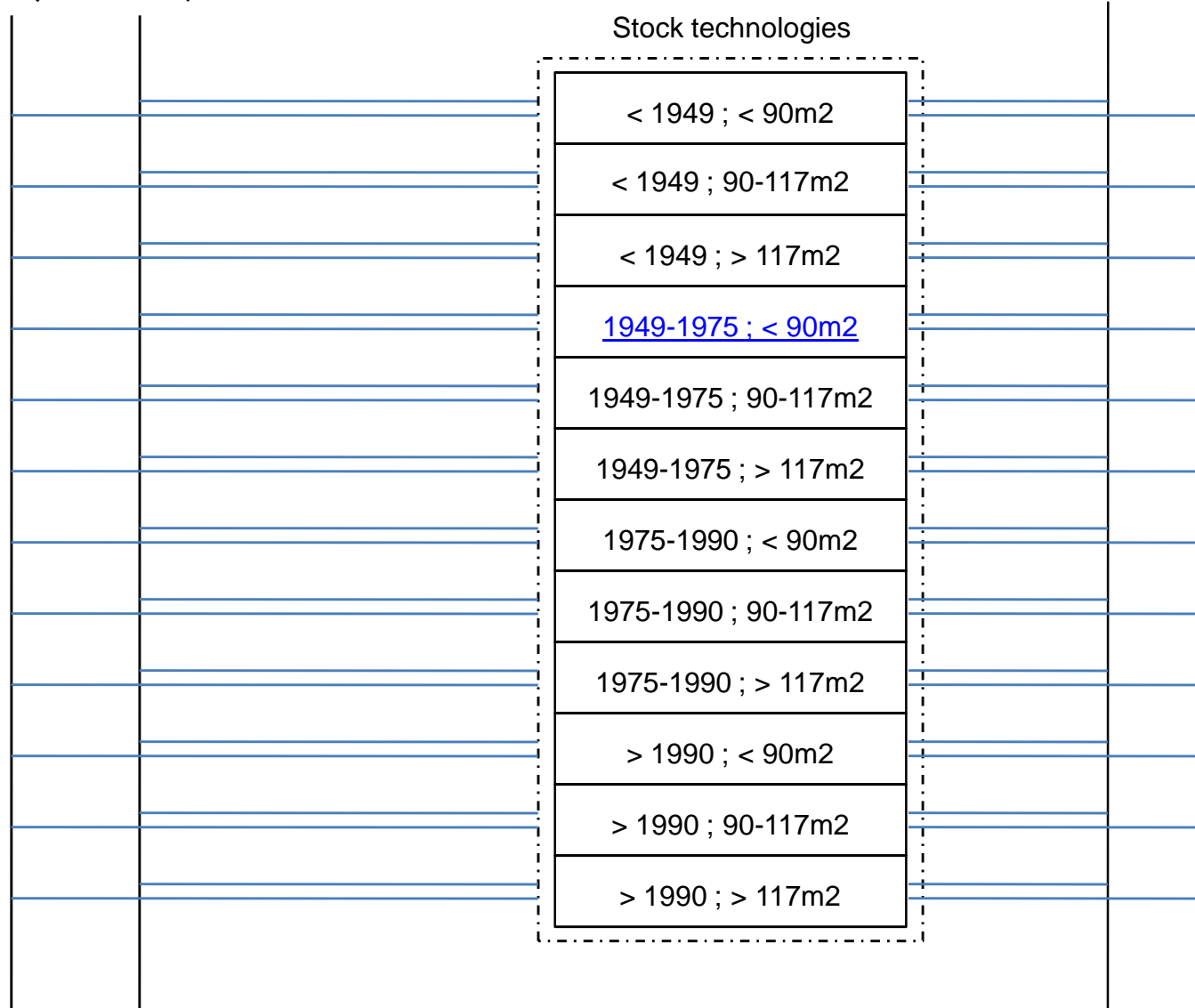
IH Space Heating

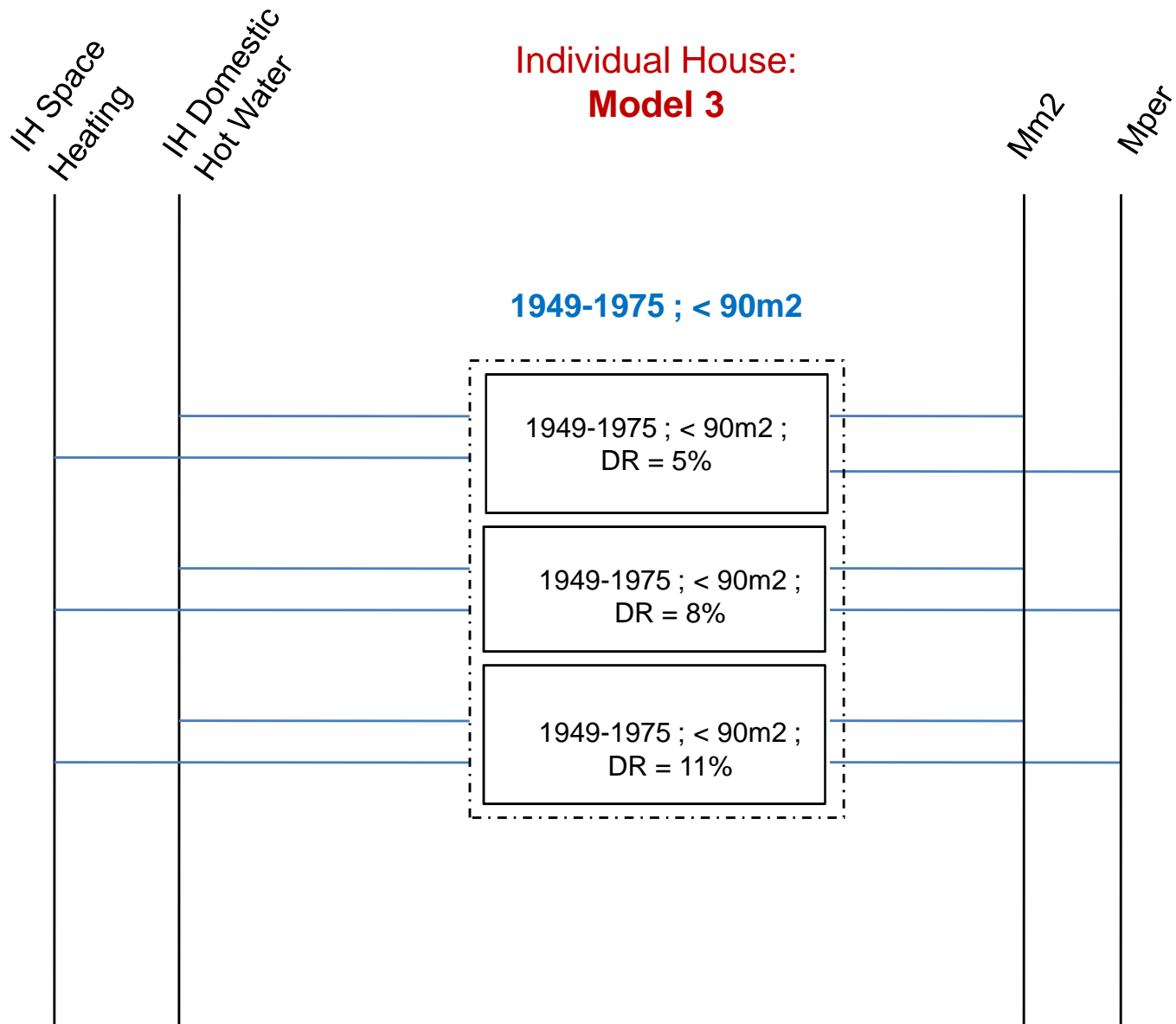
IH Domestic Hot Water

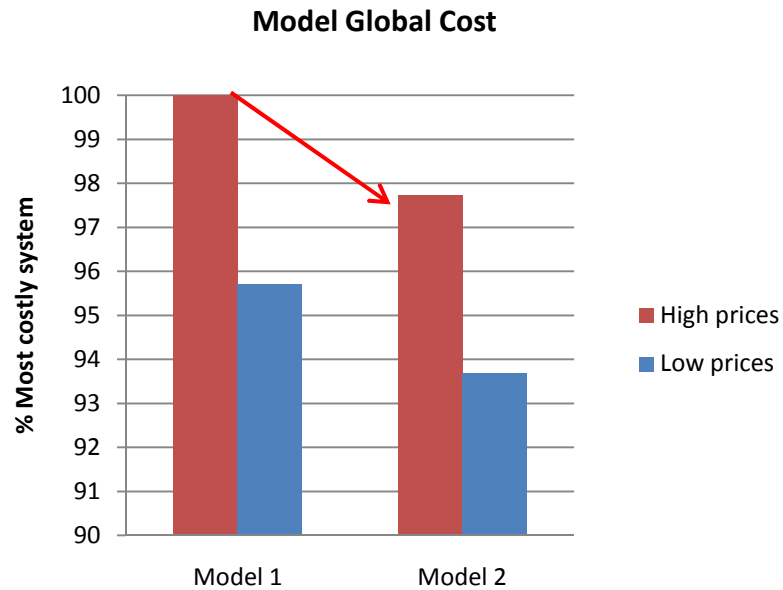
Individual House Model 2

Mm2

Mper







- **Small decrease** of the Global System Cost: - **2%**

- Technology choices are more adapted to each segment