Households under carbon constraint: TIMES model of French Residential & Transports sectors

Jean-Michel CAYLA, Mines ParisTech/EDF
Nadia MAIZI, Mines ParisTech

ETSAP Workshop : Stockholm
Thursday June 24th 2010

OUTLINES

1 – Presentation of the Model

2 – Reference Scenario Results : Residential sector

3 – Carbon constraint scenario Results

Question

In the context of a F4 in 2050 for C02 emissions

• What are the optimal **technologies** and the optimal **timing** to invest ?

• How the **burden is shared between households** ?

•What does this optimal allocation implies in term of **policies** to reach F4

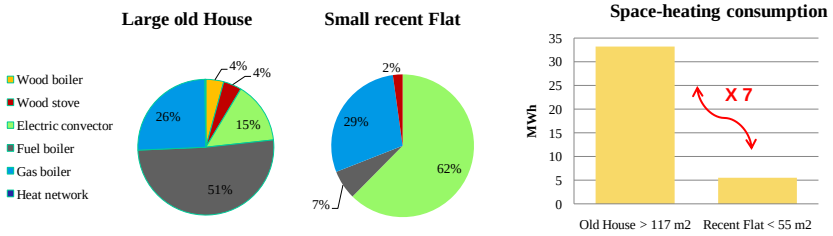
→ TIMES Model with a very detailed household's energy demand

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

1 –Desaggregate the energy demand

• Inclusion of household's attributes that are playing a role in:

- **Access to substitute technologies**
- **Level of energy demand**
- **Behaviour** : Investment (implicit hurdle rates) and Service factor



ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

1 – Impact of the Income in the model (1/2)

• **Capital constraint** on annual investment

→ **5,5%** annual income allocated for investment in vehicle, space-heating system, insulation & durable goods (INSEE 2006)

Price of equipments and Annual share of households that invest are varying with Income quintile

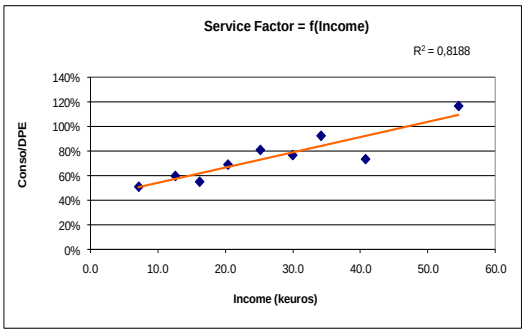
• **Implicit Hurdle rates** is varying with income quintile (EDF survey 2009)

→ **10.5%** Space-heating
25% Appliances
8.5% Personal Vehicle

1 – Impact of the Income in the model (2/2)

• Also plays a significant role in the **service factor** level

Ratio **deduced/normative** space-heating consumption



Normative : DPE-3CL method, used for French Dwellings Labelling
Deduced: Deduced from Households energy bills (EDF survey 2009)

1 – Residential Model (1/2)

- 180 segments of homogeneous households : 6 variables

Role	Variable	Segmentation	Effect
Access to technologies	**Type Housing**	House/Flat	No wood , Solar SHW for Flats
	Ownership status	Landlord/Tenant	No insulation for tenants
Level of Demand	**Area**	Hou : 70m2/100m2/150m2 Fl : 42m2/67m2/94m2	Space heating & lighting demand
	Thermal Insulation	3 quality levels	Initial thermal quality for roof, walls, windows & ventilation
	Income	5 income quintiles	Space-heating service Factor
	Size of household	Single/Couple w/wo children	Level of demand for SHW, cooking, appliances
Behaviour	**Income**	5 income quintiles	Implicit Hurdle Rate Capital constraint

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

1 – Residential Model (2/2)

• The levels of demand are driven by households attributes

End-use	Pertinent Unit	Attribute driver	Number New Techs
Space-heating	kWh utile	Surface, Income	7
Water heating	kWh utile	Size household	5
Cooking	kWh utile	Size household	4
Lighting	Lightbulbs	Surface	4
Froid	Litres	Size household	6
Lavage	Wash. cycles	Size household	4

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

1 – Transports Model (1/2)

- 120 segments of homogeneous households : 5 variables

Role	Variable	Segmentation	Effect
Access to technologies	**Urban area**	City/suburban/exurban/rural	Collective Transports Offer
	Vehicle Ownership	Yes/No	Access to vehicle
Level of Demand	**Urban area**	City/suburban/exurban/rural	Distance to amenities
	Activity	Active/Inactive	Intensity of mobility
	Size of household	Single/Couple w/wo children	Level of pkm
Behaviour	**Income**	5 income quintiles	Implicit Hurdle Rate Capital constraint

ParisTech INSTITUT DES SCIENCES ET TECHNOLOGIES PARIS INSTITUTE OF TECHNOLOGY 9/17

1 – Transports Model (2/2)

• The level of demand and the modal split is determined for each household's member via a regression model (urban area, activity status, car ownership)

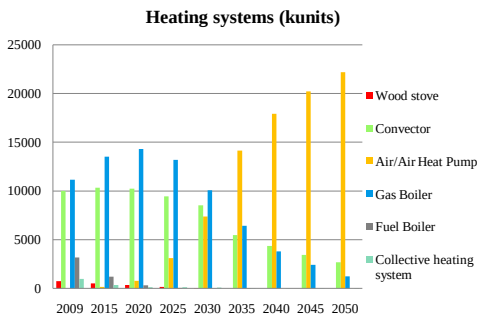
• The distances traveled by the different persons are then aggregated for the household

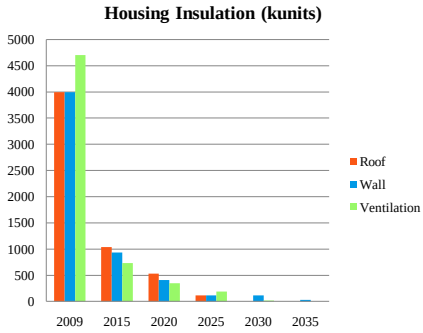
• The distance is represented as a sum of different types of distances and for each kind of distance different modes are in competition

Type of Vehicle	1 person	2 persons	3 persons	4 +persons
Local mobility				
Small size	O	O	O	X
Medium size	O	O	O	O
Large size	O	O	O	O
Long-distance travel				
Small size	O	O	X	X
Medium size	O	O	O	X
Large size	O	O	O	O

ParisTech INSTITUT DES SCIENCES ET TECHNOLOGIES PARIS INSTITUTE OF TECHNOLOGY 10/17

2 – Residential Reference Scenario Results : Equipments

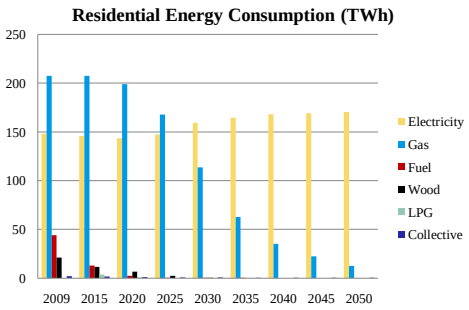


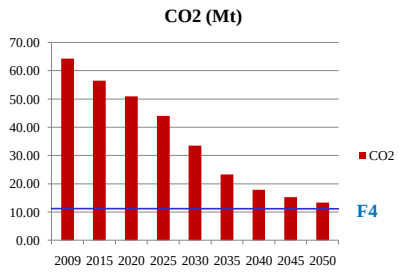


- Effect of the capital constraint on insulation investments
- Gas Boilers until 2020-2030 then air/air Heat Pumps

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

2 – Residential Reference Scenario Results : Energy consumption



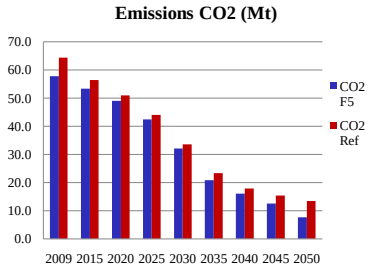


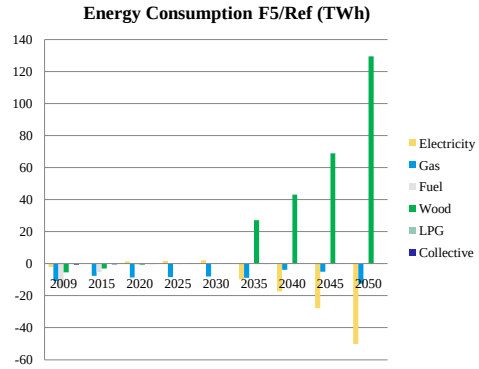
- BAU almost reaches F4 (with fixed levels of demand)
- Air/Air Heat Pumps and Thermal Insulation are cost-effective solutions to reduce CO2 emissions

ParisTech
INSTITUT DES SCIENCES ET TECHNOLOGIES
PARIS INSTITUTE OF TECHNOLOGY

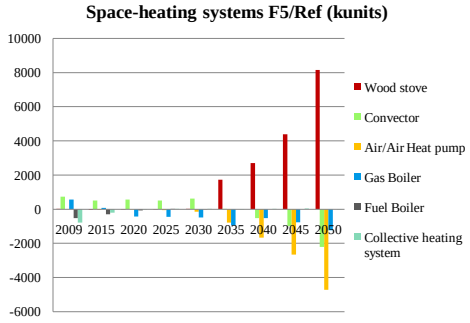
3 – Carbon constraint Scenario Results : Energy consumption

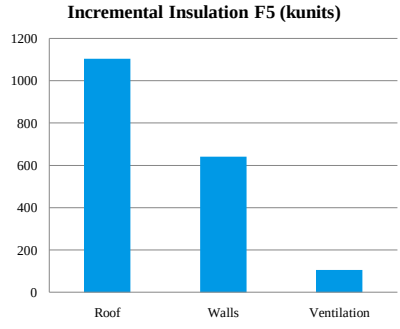
• Carbon constraint F5: -80% in 2050 (Existing + New buildings)





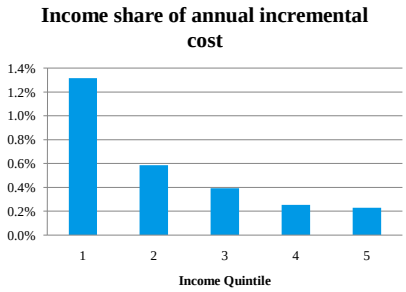
3 – Carbon constraint Scenario Results : Equipments





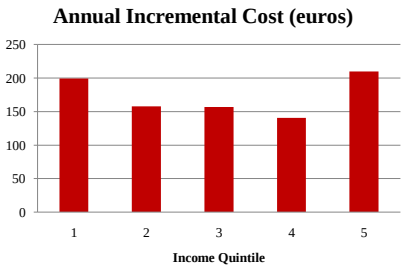
• Wood technologies in 2030 (Electricity : 60g/kWh)
• Reinforced Insulation

3 – Carbon constraint Scenario Results : Burden Sharing



At least we can see that such a constraint needs policies to adress **Equity issue**

Impact of carbon constraint in terms of incremental cost on Households Budget




ParisTech INSTITUT DES SCIENCES ET TECHNOLOGIES PARIS INSTITUTE OF TECHNOLOGY 15/17

Conclusion

• Residential sector is on a reduction trend, important emissions reductions are achieved with existing technologies and no additive policies.

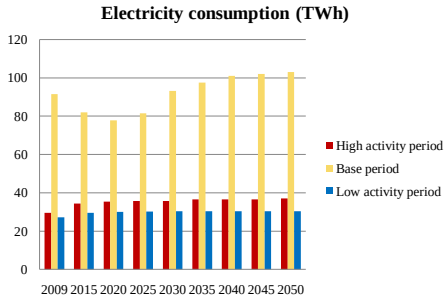
• Subventions are needed for income constrained households but these are to be joined with desincentive measures in order to avoid a strong Rebound Effect (tax or increasing tariffs)

• There is a great interest to model jointly Residential & Transports sectors to evaluate arbitrations between CO2 reductions in the 2 sectors.

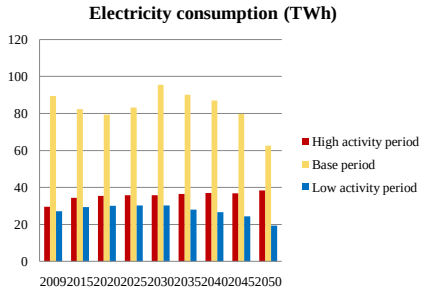

ParisTech INSTITUT DES SCIENCES ET TECHNOLOGIES PARIS INSTITUTE OF TECHNOLOGY 16/17

Appendix 1 : Electricity consumption by period

Reference Case



Carbon constraint Scenario



Appendix 2 – Energy prices

• Energy prices come from WEO 2009 projections : constant after 2030

Price	2006	2015	2030	2050
Oil barrel $05	63,5	87	115	115
Natural Gas $05	7,4	10,1	13,4	13,4

Electricity price is mainly linked to natural gas price