MINES ParisTech

EDF R&D

Households under carbon constraint: What policies for a pathway toward low-carbon consumption in France ?

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Chaire Modélisation prospective au service du développement durable

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OUTLINES

1 – Taking heterogeneity into account in our models is a priority

2 – Presentation of TIMES-Households Model for France

3 – Carbon Tax scenarios Results : impact on households budget

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Question

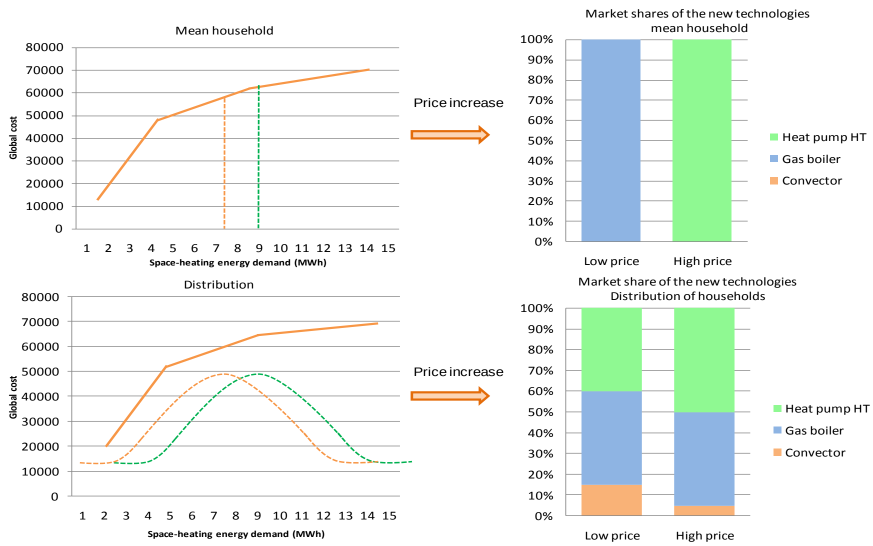
In the context of a -75% reduction CO_2 emissions in 2050

- 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** ?

→ TIMES is particularly adapted to provide insights for such questions

1 – Taking heterogeneity into account in our models is a priority

1 –Why should we take heterogenity of households into account ?



Leads to **realistic technology diffusion**, adress the bang-bang effect issue

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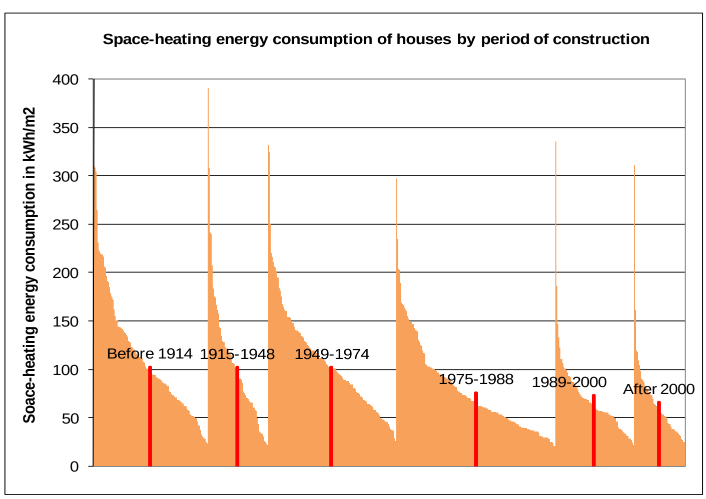
1 –Heterogenity in space-heating energy consumption



Impact of period of construction on consumption is obvious but limited

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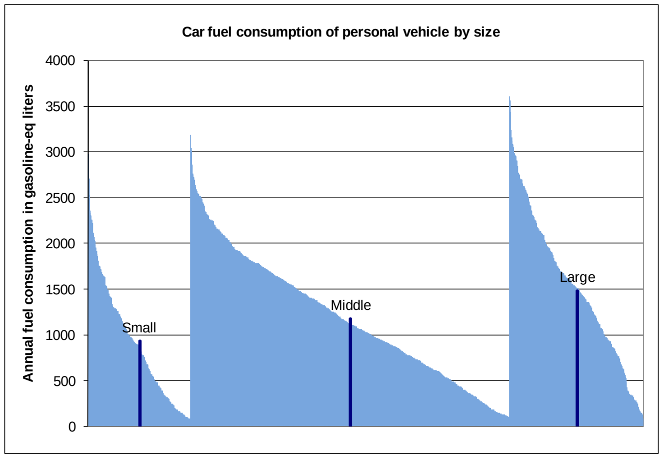
6/27

1 –Heterogeneity of car fuel consumption



Technical variables are insufficient to explain heterogenity of energy consumption
Necessity to include **behavioural parameters**

1 –How can we take heterogeneity into account in TIMES ?

$$Min(Cost_{household}) = Min\left\{\left[C_{inv} + \sum_{i=1}^{LT} \frac{Demand_{\text{household}} \times price_{Energy}}{Efficiency} \frac{1}{(1+HR_{\text{household}})^{i}}\right]\right\}$$

➢ The technology diffusion in TIMES depends on **3 types of levers** that may be differenciated among households

- Access to technology substitutes

Accessibility to collective transports
Possibility to refurbish housing

- Initial level of demand in energy services

Hot water needs, space to heat
Distance to travel to go to work
Arbitrations bewteen cost and confort

- Required rate of return

Equipment purchasing behavior : space-heating, refrigerator, vehicle

2 – Presentation of TIMES-Households Model for France

2 – Disaggregation of the energy demand in Residential sector

- 180 segments of homogeneous households : 6 variables

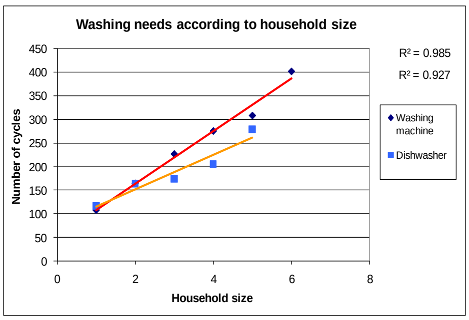
Role	Variable	Segmentation	Effect
Access to technologies	**Type Housing**	House/Flat	No wood , Solar SHW for Flats
	Ownership status	Landlord/Tenant	No insulation for tenants
Level of Demand	**Area**	Hou : 70m2/100m2/150m2 Fl : 42m2/67m2/94m2	Space heating & lighting demand
	Thermal Insulation	3 quality 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

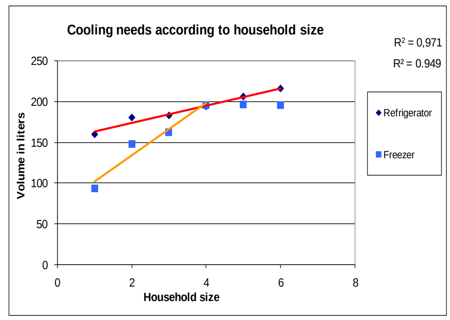
2 – Residential part of the model (1/2)

Variable	Banned technology
Appartment	Solar water-heater Heat pump air/water
Tenant	Wall insulation Roof insulation

➢ Available technologies depend on **occupation status** and **type of housing**

➢ Level of washing and cooling needs varies with **household size**

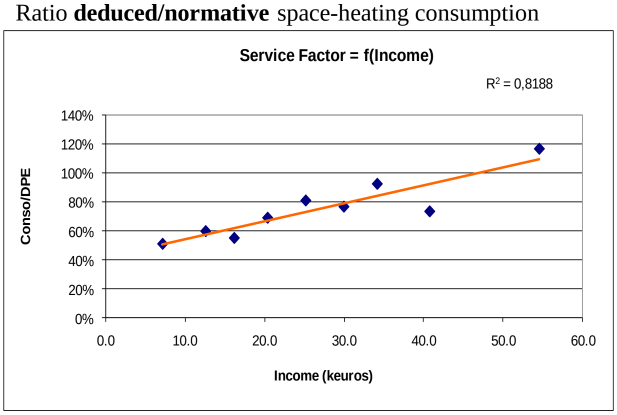




2 – Residential part of the model (2/2)

➢ Space-heating need depends on **living space** and **shell efficiency**

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



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

➢ But **Income** plays a significant role in the **service factor** level (confort level)

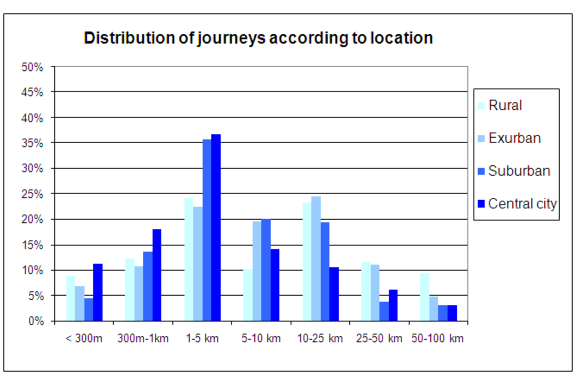
2 – Disaggregation of the energy demand in Transports sector

- 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

2 – Transports part of the model (1/2)

➢ Mobility is disaggregated as a sum of journeys of different lenght
➢ The demand for energy service corresponds to a frequency of the different type of trips
➢ The frequency varies with **activity status** and the type of trips depends on **geographical location**



Type of mobility	Distance
Local mobility	< 300m
	300m-1km
	1-5km
	5-10km
	10-25km
	25-50km
	50-100km
Long-distance Mobility	100-200km
	200-350km
	350-500km
Very long-distance Mobility	500-1500km
	1500-3000km
	3000-8000km
	> 8000km

2 – Transports part of the model (2/2)

Type	Size	Weight	Power	Household size	Market share
Small	3,5 m	< 1000 kg	< 5 CV	**< 3 pers**	19%
Middle	4 m	1000-1400kg	5-7 CV	**< 4 pers**	57%
Large	4,5 m	> 1400 kg	> 7 CV	**Tous**	24%

- Size of the car depends on **households size**
- Potential of modal report depends on **location** and type of journeys
- Vehicles fill rate and efficiency may vary with **size of the households** end type of journeys
- Potential competition between technologies depend on the distance

Distance	Location	Bus	Subway	Train
< 300m	Rural	0%	0%	0%
< 300m	Exurban	0%	0%	0%
< 300m	Suburban	0%	0%	0%
< 300m	Central City	0%	0%	0%
300m–1km	Rural	0%	0%	0%
300m–1km	Exurban	0%	0%	0%
300m–1km	Suburban	0%	0%	0%
300m–1km	Central City	0%	0%	0%
1-5km	Rural	0,1%	0,0%	0%
1-5km	Exurban	0,6%	0,1%	0%
1-5km	Suburban	2,2%	0,7%	0%
1-5km	Central City	18,6%	9,0%	0%
5-10km	Rural	0,1%	0,0%	0%
5-10km	Exurban	0,6%	0,1%	0%
5-10km	Suburban	13,1%	6,8%	0%
5-10km	Central City	17,1%	11,4%	0%
10-25km	Rural	0,1%	0,0%	0%
10-25km	Exurban	0,7%	0,1%	0%
10-25km	Suburban	13,1%	2,4%	0%
10-25km	Central City	19,9%	8,6%	0%
25-50km	Rural	0%	0,0%	0,0%
25-50km	Exurban	0%	0,3%	13,6%
25-50km	Suburban	0%	1,1%	19,3%
25-50km	Central City	0%	5,4%	18,9%
50-100km	Rural	0%	0%	6,5%
50-100km	Exurban	0%	0%	14,5%
50-100km	Suburban	0%	0%	8,9%
50-100km	Central City	0%	0%	30,9%

2 – Impact of the Income on equipment purchasing behavior

- **Capital constraint** on annual investment

  → Part of income allocated for investment in vehicle, space-heating system and insulation is constrained (Value INSEE 2006)

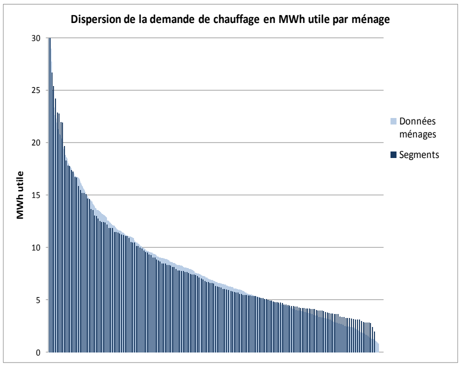
  This annual budget share dedicated to investments may vary with Income quintile

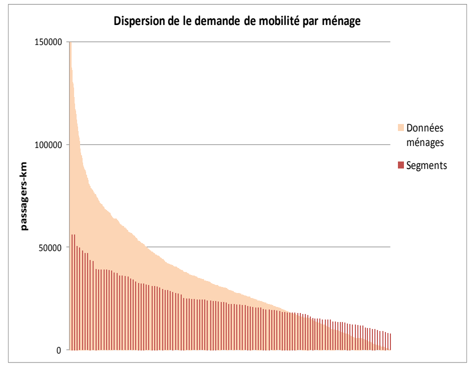
- **Implicit Hurdle rates** are varying with income quintile (EDF survey 2009)

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

2 – Effective disaggregation of the level of demand

Space-heating and mobility demand of the segments compared to survey data





TIMES-Houseolds model has reached to capture a large part of heterogeneity in energy demand

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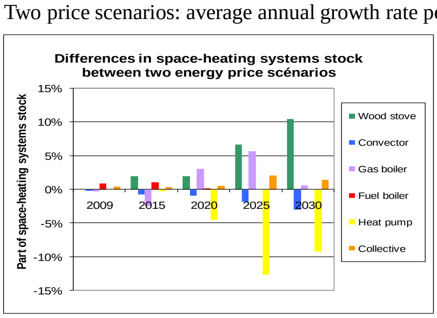
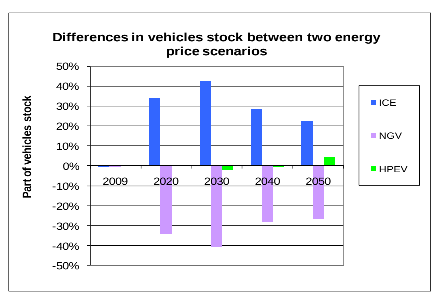
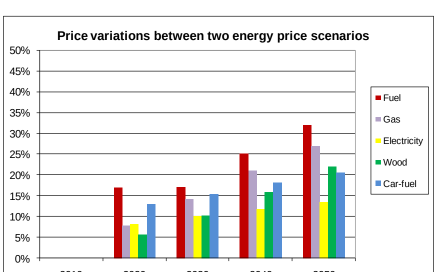
2 – Impact of the disaggregation on the results in TIMES

Two price scenarios: average annual growth rate petrol barel **1% or 2%**





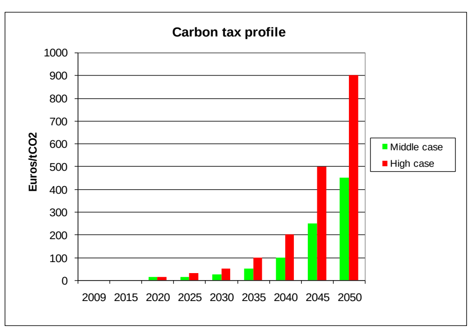


Variations in stock of technologies between the two price scenarios **are coherent with energy price variations**

3 – Carbon Tax scenarios Results and their impact on households budget

3 – Two policy scenarios to reach -75% in CO2 Emissions in 2050

➢ Reach a 75% reduction in CO2 emissions in 2050 for France **means for households** **-24%** en 2020 et **–83%** en 2050, results obtained with another model : TIMES-Fr



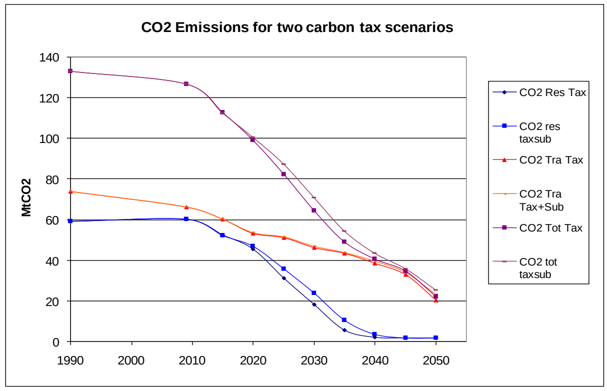
➢ « High Carbon Tax » scenario : 900euros/tCO_2 in 2050

➢ « Middle Carbon Tax + Subsidies » scenario: 450euros/tCO_2 in 2050

- 50% rebate for insulation measures for low income households
- 5000 euros subsidy for electric vehicle

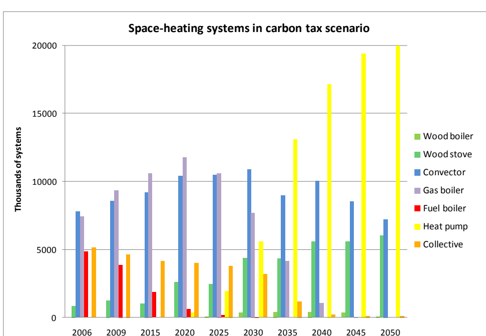
3 – Two policy Scenarios to reach -75% in CO2 Emissions

- Both « high carbon tax » and « mid carbon Tax + Subsidies » scenarios reach F4 in 2050

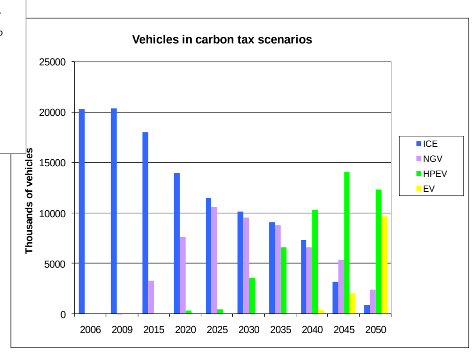


- The type of technology diffused are quite the same in both carbon tax scenarios
- The **difference** lies in the **kind of households who buy them**

3 – Carbon tax scenarios results : Equipments (1/2)

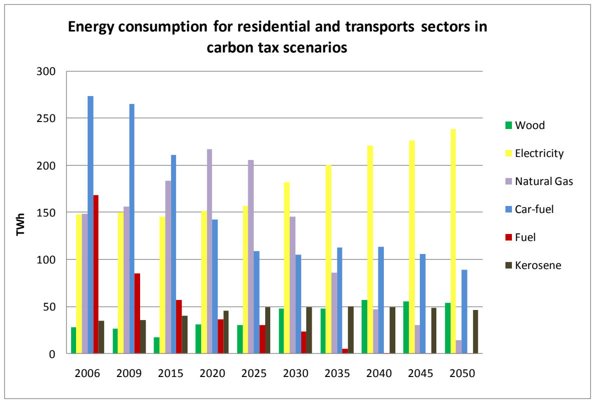


- PHEV's are developping in 2030
- **EV's** are the **last solution deployed** → **very costly** as they don't allow to go to long distance



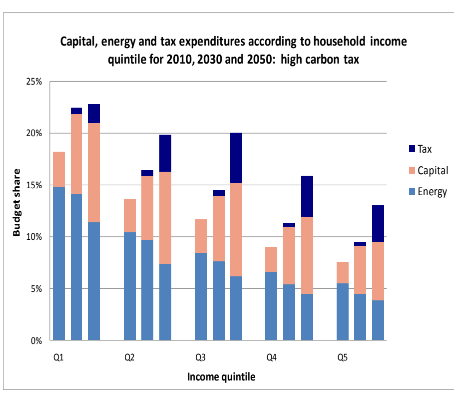
- **Strong insulation** of dwellings
- 2 key-technologies to reach -75% reduction : **Heat pumps and HPEV/EV**

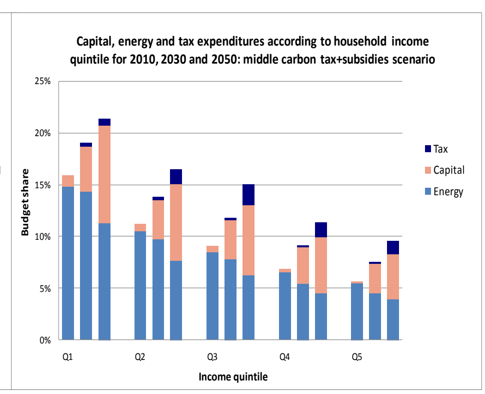
3 – Carbon tax scenarios results : Equipments (1/2)



➢ There is an increase of electricity consumption by 90 TWh in 2050
➢ Natural gas consumption is increasing until 2020 and decreasing after: Good solution to reduce a little CO2 emissions not to reduce a lot

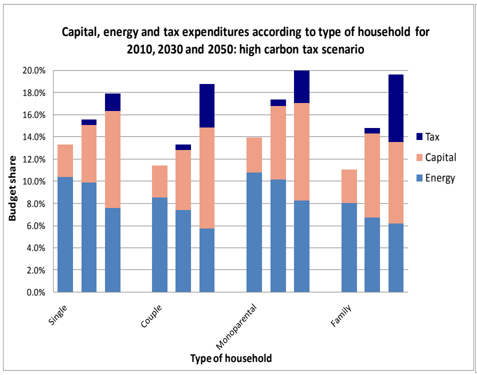
3 – Impact on households budget : income (1/3)

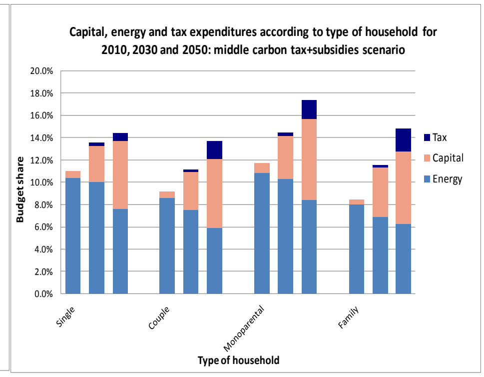




➢ **Least well-off households** experience an increase of their budget share allocated to energy

3 – Impact on households budget : type of household (2/3)

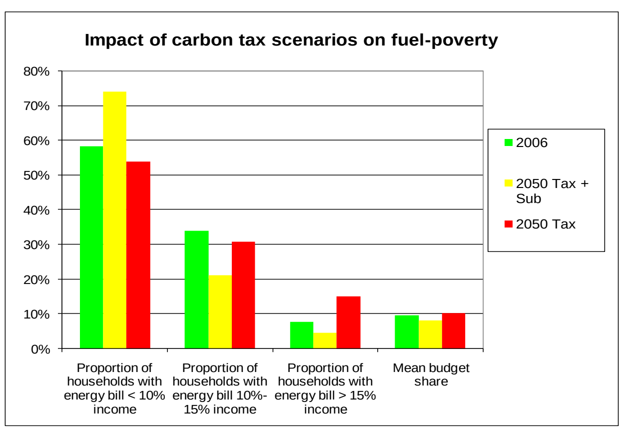




➢ **Families and especially monoparental families** experience an increase of their budget share allocated to energy

➢ The amount of carbon tax payed by households is decreasing when tax is accompagnied by subsidies → **efficiency of carbon tax is enhanced by subsidies**

3 – Impact on households budget : fuel-poverty (3/3)



➢ This policy tool may **lower the distorting effect** of the single carbon tax as fuel-poverty decreases.

Conclusion

Key-messages

- To reach a strong CO2 emissions decrease : **Insulation** of dwellings, **heat pumps** and **PHEV/EV**'s with a **low carbon electricity** are required
- Carbon tax is a powerfull policy tool but its efficency is **reinforced by** targeted **subsidies** (amount of subsidies reaches **35% of total tax revenue**)
- Subsidies may adress the issue of inequity in the burden sharing and may also help to reduce fuel-poverty

Methodology

- TIMES-Households captures the heterogeneity of the households energy demand in including both technical and behavioural components and leads to realistic technology diffusion
- This model provides useful insights about the detailed impact of policy tools. It would be very useful to link it to a macroeconomic model

Appendix 1 –

- Hypothesis en 2050
  - Biofuels **4Mtep**
  - Electricity emissions 10gCO2/kWh