Evaluation of Medium/Long term Energy Efficiency Potentials

Case studies on end-use models

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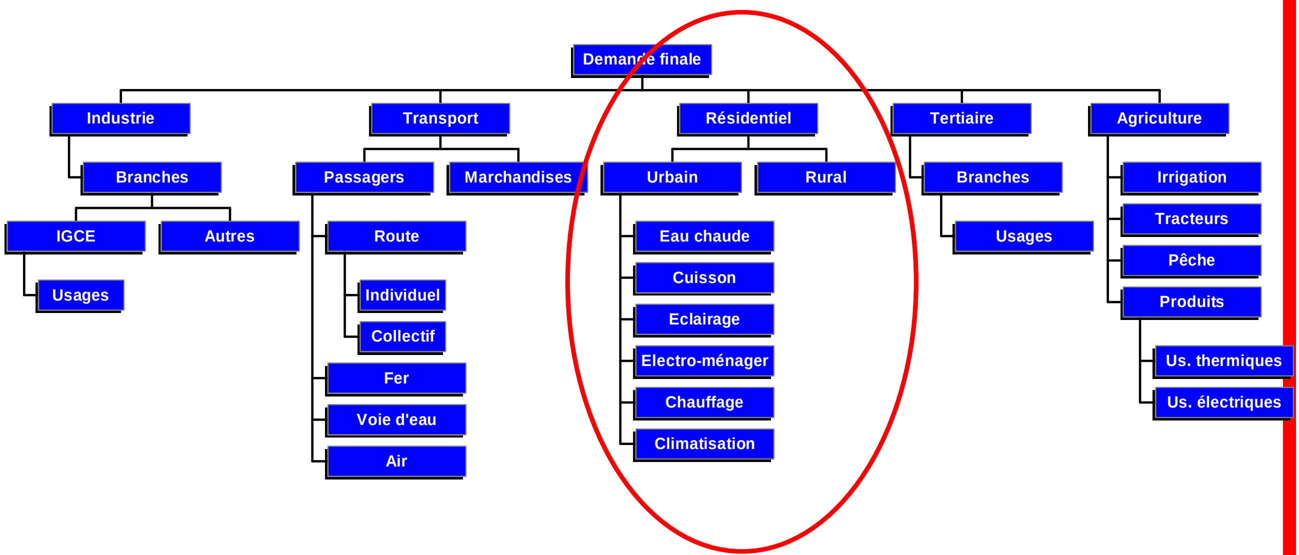
Techno-economic (end-use) models: general architecture



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Modelling energy demand for households : global approach vs by end-use / equipement

Ł Global approach
-fuels
-electricity

Ł Approach by end-use / equipment
-cooking
-water heating
-heating
-captive uses of electricity (lighting, household appliances)

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Modelling energy demand for households : global approach

Ł Demand : unit consumption x number of households
Ł unit consumption of fuel (toe/household)
Ł unit consumption of electricity (kWh/electrified household)

==Ł Advantages: simplicity (data, implementation)
==Ł Limits: difficulty to simulate substitutions (cooking, space heating), and to account for energy savings

Modelling energy demand for households :
detailed approach by end-use / equipment

- Captive uses
  - lighting
  - electrical appliances by type

- Substitutable Uses
  - cooking
  - water heating
  - heating

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Modelling energy demand for households :
detailed approach : lighting and electrical appliances

Basic equation

Ee=MEN X TEQe X Cue

$$E = \Sigma Ee$$

with:

e: Type of equipment

MEN: Number of households

TEQ: Rate of equipment ownership (% of households with equipment e)

CU : Unit consumption (kWh/year)

====> Choice of the level of disaggregation
e= 1, 2 …. 5 ?? (Refrigerators, Freezers, TV, Dish-Washer …)

Case Study 1 : Exercise 1

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Mtoe	LPG	Oil	Gas	Electricity	Wood	Total
Heating/ hot water		0.3 x 30 = **9**	0.37 x 30 = **11.1**	0.1 x 30 = **3**	30 – 9 - 11.1 - 3 = **6.9**	30.00
Cooking	0.41 x 24 x 0.1 = **0.98**		0.28 x 24 x 0.15 = **1.01**	0.31 x 24 x 0.11 = **0.82**		2.81
Lighting		120 x 0.8 x 0.3 x 24 / 1000 =**0.69**		0.7 x 24 x (400 x 0.086) /1000 = **0.58**		1.27
Refr.				500 x 24 x 0.7 x 0.95 x 0.086 /1000 = **0.69**		0.69
TV				100 x 24 x 0.7 x 0.9 x 0.086 / 1000 = **0.13**		0.13
Others				8 – 3 – 0.82 – 0.69 – 0.13 = **2.79**		2.79
Total	0.98	9.69	12.11	8	6.9	37.68

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Case Study 1 : Exercise 2 (Ass 1)

Assumption 1: the electricity consumption per electrified household is stable

	Unit	2000	2020
Electricity consumption per electrified hh	toe/hh	8 / (0.70x24)=0.48	0.48
Electricity consumption	Mtoe	8	0.48 x (0.95x30) =**13.57**

Case Study 1 : Exercise 2 (Ass 2)

Assumption 2: the electricity consumption per electrified household increase with a 0.5 elasticity to the income

HH_{2020}/HH_{2000}= (30/24)^(1/20) =1.12%/year

D(GDP/HH) = 2.5-1.12 = 1.38%

When the income per household increase by 1% , the electricity consumption per household increase by 0.5.
Here the income per household is increasing by 1.38%year; so the electricity consumption per household is increasing by: 1.38 x 0.5 = 0.69%year

We know that electricity consumption per electrified hh in 2000 is 0.48 toe/hh

=> the electricity consumption per electrified hh in 2020 is:
0.48 x (1+0.0069)^20 = 0.55 toe/hh (=> 6404 kWh)

=> The country 's electricity consumption in 2010 is:
0.55 x (30*0.95) = **15.57 Mtoe** (=> 144.88 TWh)

Case Study 1 : Exercise 3

Urban	**Consumption in 2000 (TWh)**
Total, of which	35 TWh
Lighting	All the electrified hh use lighting Cons: 11.7 x 400 /1000 = **4.68 TWh**
TV	Nb of hh with TV: 0.7x15.6=10.92 M Cons: 100 X 10.92 / 1000 = **1.09 TWh**
Refrigerators	Nb of hh with refr.:0.7x15.6 = 10.92 M Cons: 500 x 10.92 / 1000 = **5.46 TWh**
Others	35 – 4.68 – 1.09 – 5.46 = **23.77 TWh**

Nb of households:

0.65 x 24 = 15.6 M

Nb of electrified households:

0.75 x 15.6 = 11.7 M

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Case Study 1 : Exercise 3

Rural	Consumption in 2000(TWh)
Total, of which	13.6 TWh
Lighting	All the electrified hh use lighting Cons: 5.04 x 400 /1000 = **2.016 TWh**
TV	Nb of hh with TV: 0.5x8.4 = 4.2 M Cons: 100 X 4.2 / 1000 = **0.42 TWh**
Refrigerators	Nb of hh with refr.:0.6x8.4 = 5.04 Cons: 300 x 5.04 / 1000 = **1.512 TWh**
Others	13.6 – 2.016 – 0.42 – 1.512 = **9.652 TWh**

Nb of households:

0.35 x 24 = 8.4 M

Nb of electrified households:

0.60 x8.4 = 5.04 M

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Case Study 1 : Exercise 4 (Ass 1)

Urban	Consumption in 2020(TWh)
Total, of which	10.098 + 2.347 + 11.735 + 51.29 = **75.46 TWh**
Lighting	All the electrified hh use lighting Cons: 25.245 x 400 /1000 = **10.098 TWh**
TV	Nb of hh with TV: 0.7x(1+0.0138)^20x25.5 =23.47 M Cons: 100 X 23.47 / 1000 = **2.347 TWh**
Refrigerators	Nb of hh with refr.: 0.7x(1+0.0138)^20x25.5 = 23.47 M Cons: 500 x 23.47 / 1000 = **11.735 TWh**
Others	23.77 / 11.7 x 25.245 = **51.29 TWh**

Nb of households:

0.85 x 30 = 25.5 M

Nb of electrified households:

0.99 x 25.5 = 25.245 M

Case Study 1 : Exercise 4 (Ass 2)

Urban	Consumption in 2020(TWh)
Total, of which	10.098 + 3.075 + 11.735 + 51.29 = **76.19 TWh**
Lighting	All the electrified hh use lighting Cons: 25.245 x 400 /1000 = **10.098 TWh**
TV	Nb of hh with TV: 0.7x(1+**0.0276**)^20x25.5 =30.075 M Cons: 100 X 30.075 / 1000 = **3.075 TWh**
Refrigerators	Nb of hh with refr.: 0.7x(1+0.014)^20x25.5 = 23.47 M Cons: 500 x 23.47 / 1000 = **11.735 TWh**
Others	23.77 / 11.7 x 25.245 = **51.29 TWh**

Nb of households:

0.85 x 30 = 25.5 M

Nb of electrified households:

0.99 x 25.5
= 25.245 M

Case Study 1 : Exercise 4 (Ass 3)

Urban	Consumption in 2020(TWh)
Total, of which	6.867 + 2.46 + 9.388 + 51.29 = **70.000 TWh**
Lighting	All the electrified hh use lighting Cons: (0.4 x25.245 x (400x0.2)+ 0.6 x 25.245 x 400) /1000 = **6.867 TWh**
TV	Nb of hh with TV: 0.7x(1+**0.0276**)^20x25.5 =30.075 M Cons: (100x0.8) X 30.075 / 1000 = **2.460 TWh**
Refrigerators	Nb of hh with refr.: 0.7x(1+0.014)^20x25.5 = 23.47 M Cons: (500x0.8) x 23.47 / 1000 = **9.388 TWh**
Others	23.77 / 11.7 x 25.245 = **51.290 TWh**

Nb of households:

0.85 x 30 = 25.5 M

Nb of electrified households:

0.99 x 25.5
= 25.245 M

Case Study 2 : Exercise 1

	Number of cars (NBCA)	Diesel demand of cars (FCCA)
Formula	$NBCA_{t+5} = NBCA_t \times (1+GRNBCA)^5$	$FCCA_{t+5} = NBCA_{t+5} \times UCCA_t$ With $UCCA_t = FCCA_t/NBCA_t$
Unit	M	Mtoe
2005	4.400 x (1+0.045)^5 = **5.483**	2.100 / 4.400 x 5483 = **2.617**
2010	5.483 x (1+0.045)^5 = **6.833**	=2.100 / 4.400 x 6833 = **3.261**

Case Study 2 : Exercise 2

	Number of cars (NBCA)	Unit consumption of cars (UCCA)	Diesel demand of cars (FCCA)
Form	$NBCA_{t+5} = NBCA_t \times (1+(GRGDPxELGDP)^5$	$UCCA_{t+5} = UCCA_t \times (1+GRUCCA(t))^5$	$FCCA_{t+5} = NBCA_{t+5} \times UCCA_{t+5}$
Unit	M	toe	Mtoe
2000	4.400	2.100 / 4.400 = **0.48**	
2005	4.400 x (1+(0.3x1.5)^5 = **5.101**	0.48 x (1-0,01)^5 = **0.45**	5.101 x 0.45 = **2.315**
2010	5.483 x (1+(0.3x1.5)^5 = **6.357**	0.45 x (1-0.02)^5 = **0.41**	6.357 x 0.45 = **2.608**

Case Study 2 : Exercise 3

	Number of cars (NBCA)	Specific consumption of cars (SCCA)	Average distance driven per car (KMCA)	Diesel demand of cars (FCCA)
Form		$SCCA_t = UCCA_t / CFDS / KMCA_t$ $SCCA_{t+5} = SCCA_t \times (1+GRSCCA)^5$	$KMCA_{t+5} = KMCA_t \times (1+(GRPRGS \times ELPRGS)^5$	$FCCA_{t+5} = NBCA_{t+5} \times UCCA_{t+5} \times CFDS \times KMCA_{t+5}$
Unit	M	l/100km	km	Mtoe
2000	4.400	0.48 / 0.88 / 8000 x 100000 = **6.78**	8000	2.100
2005	5.101	6.78 x (1-0,01)^5 = **6.45**	8000 x (1 + 0,01 x -0.1)^5 = **7960**	6.45 x 5.101 x 0.88 x 7960 / 100000 = **2.304**
2010	6.357	6.45 x (1-0.02)^5 = **5.83**	7960 x (1 + 0 x -0.1)^5 = **7960**	5.83 x 6.357 x 0.88 x 7960 / 100000 = **2.595**

Case Study 2 : Exercise 4

Elasticity of the number of cars to GDP:

dNBCA/NBCAt / dGDP/GDPt

Where dY/Y is the average yearly variation

(4.400/1.840)^(1/10) / (205474/144569)^(1/10)

= **1.05**

Case Study 2 : Exercise 4

	Number of cars (NBCA)	Specific consumption of cars (SCCA)	Average distance driven per car	Diesel demand of cars (FCCA)
	$NBCA_{t+5} = NBCA_t$ x (1+(GRGDPxELGDP)^5			
Unit	M	l/100km	km	Mtoe
2000	4.400	6.78	8000	2.100
2005	4.400 x (1+ (**0.02 x 1.05**) ^5) = **4.883**	6.45	7960	6.45 x 7960 x 5.141 x 0.88 / 100000 = **2.205**
2010	5.141 x (1 + (**0.03 x 1.05**)^5 = **5.705**	5.83	7960	5.83 x 7960 x 6.006 x 0.88 / 100000 = **2.329**

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Case Study 2 : Exercise 5

I finally took the assumption of a potential of 10% instead of 30% and I keep the data for the exploitation. These assumptions are more consistent with the reality.

	Number of cars (NBCA)	Specific consumption of cars (SCCA)	[illegible]	[illegible] cars
		$SCCA_{t+5} = SCCA_t$ x (1+($POTCA_{t+5}$x$TEXCA_{t+5}$))^5		
Unit	M	l/100km	km	Mtoe
2000	4.400	6.78	8000	2100
2005	5.141	6.78 x (1+(-**0.1x0.2**)) = **5.82**	7960	5.82 x 7960 x 5.141 x 0.88 / 100000 = **1.991**
2010	6.006	6.45 x (1+(-**0.1x0.5**)) = **4.50**	7960	4.5 x 7960 x 6.006 x 0.88 / 100000 = **1.800**