Technical potential of smart grids: an assessment of load shifting actions in France

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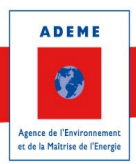


Summary[1]

- Purpose
  Assessing the load shifting potential and the impact on peak load and carbon emissions

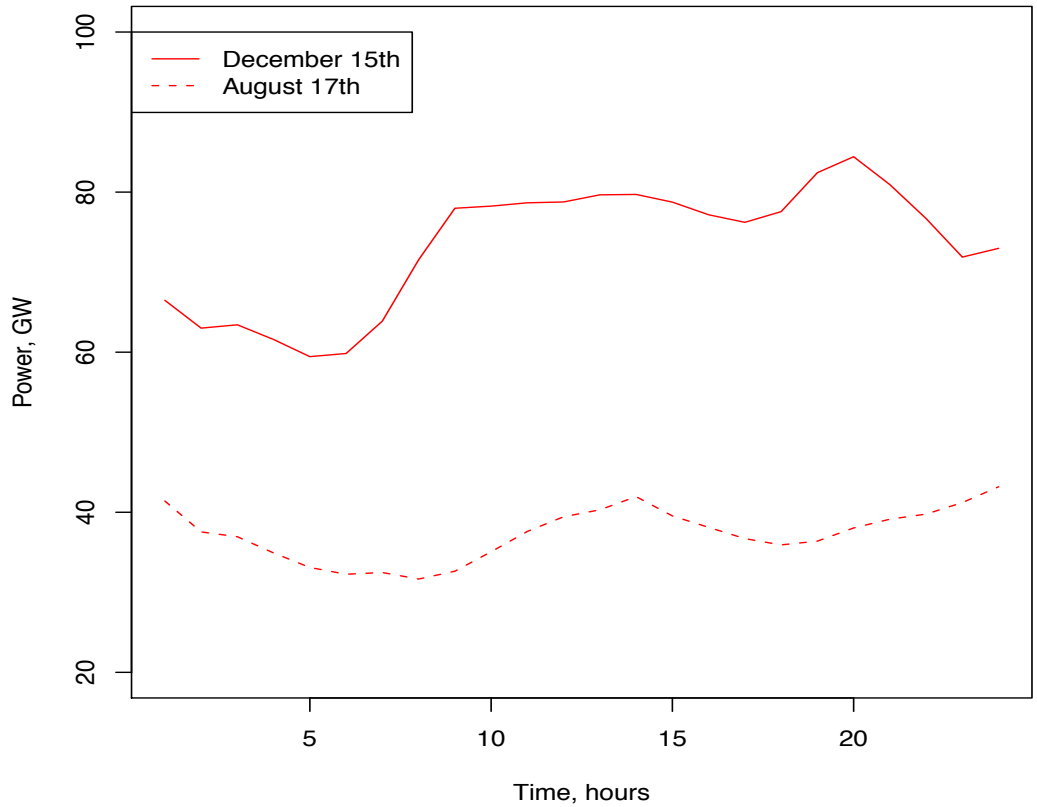
- Take-home messages
  1. Peak loads can be shaved significantly
  2. Impact on carbon emissions is low or undetermined
  3. Energy efficiency is likely to be more effective to mitigate carbon emissions

[1] The opinions expressed in this paper are only those of the authors and do not reflect ADEME's official positions.

Context

1. Matching power supply and demand is increasingly difficult
   - Technically: assuring no black-out
   - Economics: under-using installed capacity is costly and the number of producers is increasing
   - Environment: mitigating carbon emissions and increasing renewable power
2. The load is time dependant
3. The generation mix is time dependant
4. Carbon contents of power generation are heterogeneous

Daily load curves



Source: Réseau de Transport d'Electricité (RTE)

Power generation

	Capacity GW	Generation TWh	Type	Carbon content gCO_2/kWh
Nuclear	63.3	418.3	Base	0
Hydro	25.3	68.0	Base and peaks	0
Fossil fuel thermal	24.6	53.1	Peaks	[360;960]
Renewables	4.3	9.7	Intermittent	0
Total	117.6	549.7		

Source: RTE

Methodology

1. Estimating the daily potential for decreasing hourly consumption, for the 6 hours during which consumption is highest;
2. Estimating the shifts in generation, i.e. shifts from the 6 hours during which consumption is highest to the 6 hours during which consumption is lowest;
3. Estimating the impact on the peak load and on GHG emissions;
4. Two cases are considered: French grid vs European grid

Consumption and generation shifts

1. Consumption
   - Considered appliances

Device	Market penetration	Features
Washing-machine	95%	42% stdf
Dishwasher	50%	100% stdf
Electric water heater	12M	90% with storage
Refrigerator	100%	
Tumble dryer	33.2%	100% stdf

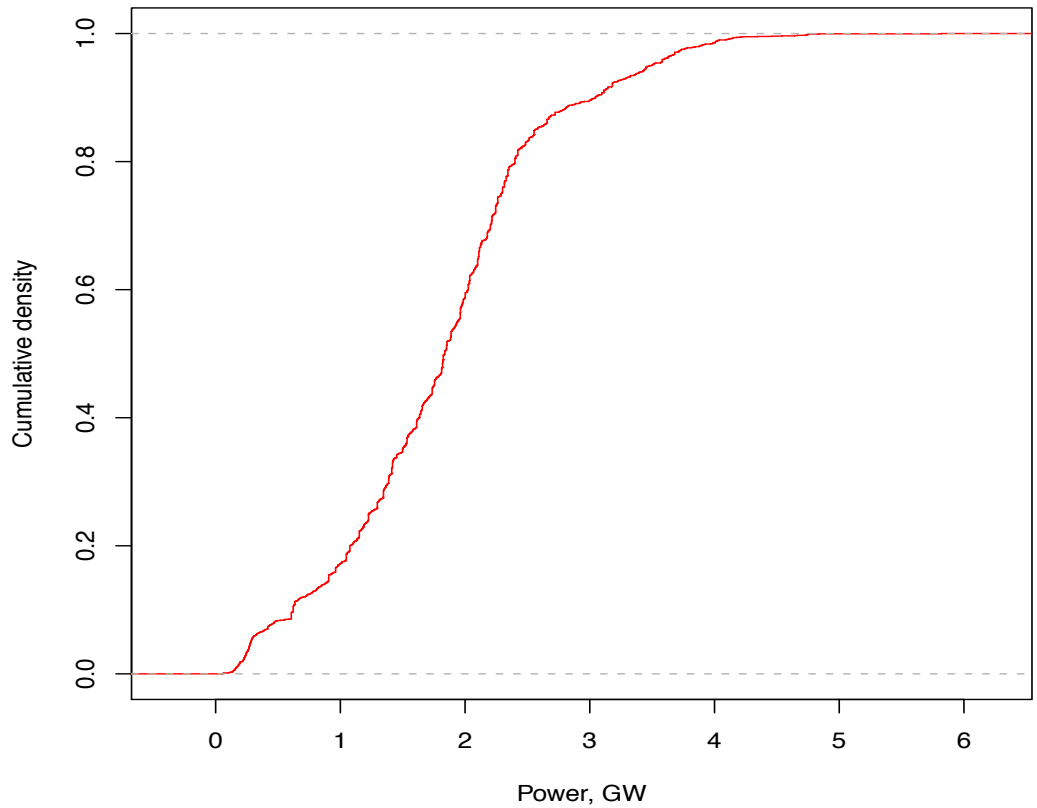
   - CHARTER database: estimated hourly consumption, per appliance, type of day, demand sector
2. Generation : merit order analysis on hourly generation mix data
   Oil-fired power is the most expensive, then Coal & Gas

Results - No interconnection

	Unit	Quantity
Decrease in yearly peak load	GW	2.99
Total potential shifted consumption	GWh	6,536
Total actual shifted consumption	GWh	3,440
Decrease in oil-fired power generation	GWh	767
Increase in coal- & gas-fired power generation	GWh	767
Decrease in CO_2 emissions	kt	109

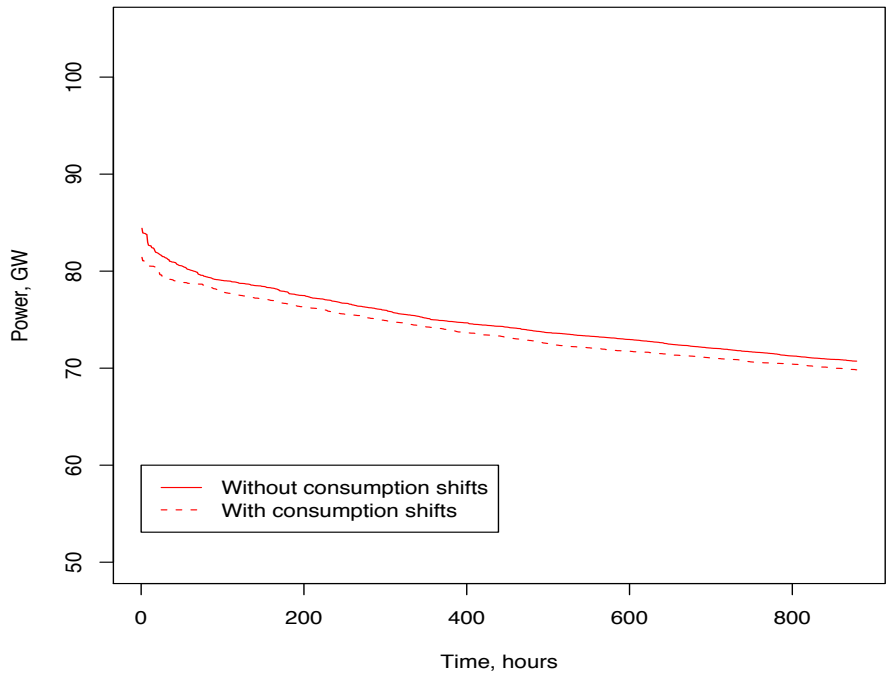
Results - No interconnection (2)

Cumulative distribution function of shifts in peak hours consumption



Results - No interconnection (3)

Load duration curve



Interconnections and generation mixes

	Interconnections			Carbon content
	Capacity GW	Imports GWh	Exports GWh	gCO_2/kWh
Belgium	3.4	1,879	10,871	249
Switzerland	3.2	7,689	26,069	27
Germany	2.7	18,969	6,385	441
Italy	2.6	1,814	19,607	398
United-Kingdom	2.0	1,409	12,743	487
Spain	1.3	3,002	5,753	326

Source: ENTSOE, RTE and IEA

Results - European mix

	Emissions gCO_2/kWh	Peak hours GWh	Off-peak hours GWh
Oil	800	-767	0
French coal&gas	658	-2673	?
Imports	329	0	?
Exports	0	+1,906	0
Consumption shifts		-5,346	+ 5,346

Carbon content of *French consumption*: either +1.1 Mt or + 0.6 Mt

What about energy efficiency?

Table: Evaluation of energy efficiency gains

	Per-unit consumption		Total consumption		Gains	
Appliance	Average kWh	Best GWh	Average GWh	Best GWh	Energy GWh	CO_2 kt
Washing-machine	169	120	4,259	1,270	2,989	179
Dishwasher	273	272	3,621	3,607	13	1
Water heater	1,920	730	23,328	7,978	15,350	614
Refridferators	253	140	6,644	3,676	2,967	119
Tumble-dryers	408	321	3,593	2,827	766	46
Total						959

Conclusion: Smoothing or down-shifting the load curve?

1. There exists a significant potential for smoothing the load curve
2. However, the impact on CO_2 emissions is low or undetermined
3. Energy efficiency seems to be much more effective than load smoothing as far as CO_2 emissions mitigation is concerned
4. Smart grids real potential: help integrate renewable power