ECN

Energy research Centre of the Netherlands

Electric vehicles and heat pumps providing flexibility to facilitate integration of large amounts of intermittent renewables

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BACKGROUND

Major future issue in electricity grids is the integration of a large share of intermittent sources such as wind energy

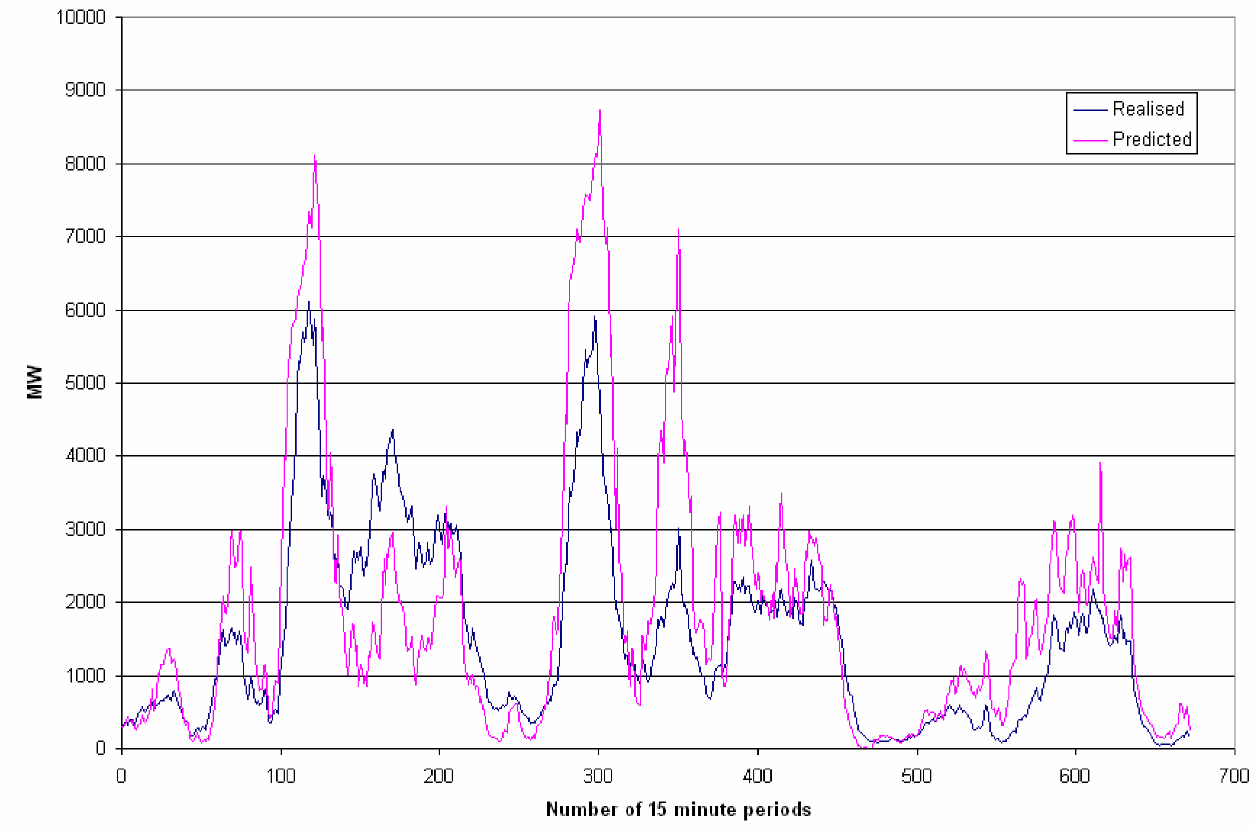
Demand response is one of the potential solutions to this problem

Intelligent E-Transport Management (ITM) project is funded by Netherlands energy agency SenterNovem. Main objective is to assess:

- Extent with which day-night differences, stability and quality of the grid can be improved by intelligent management of electric vehicles and heat pumps;

Partners in ITM are Kema, ECN, IWO, Continuon and Essent

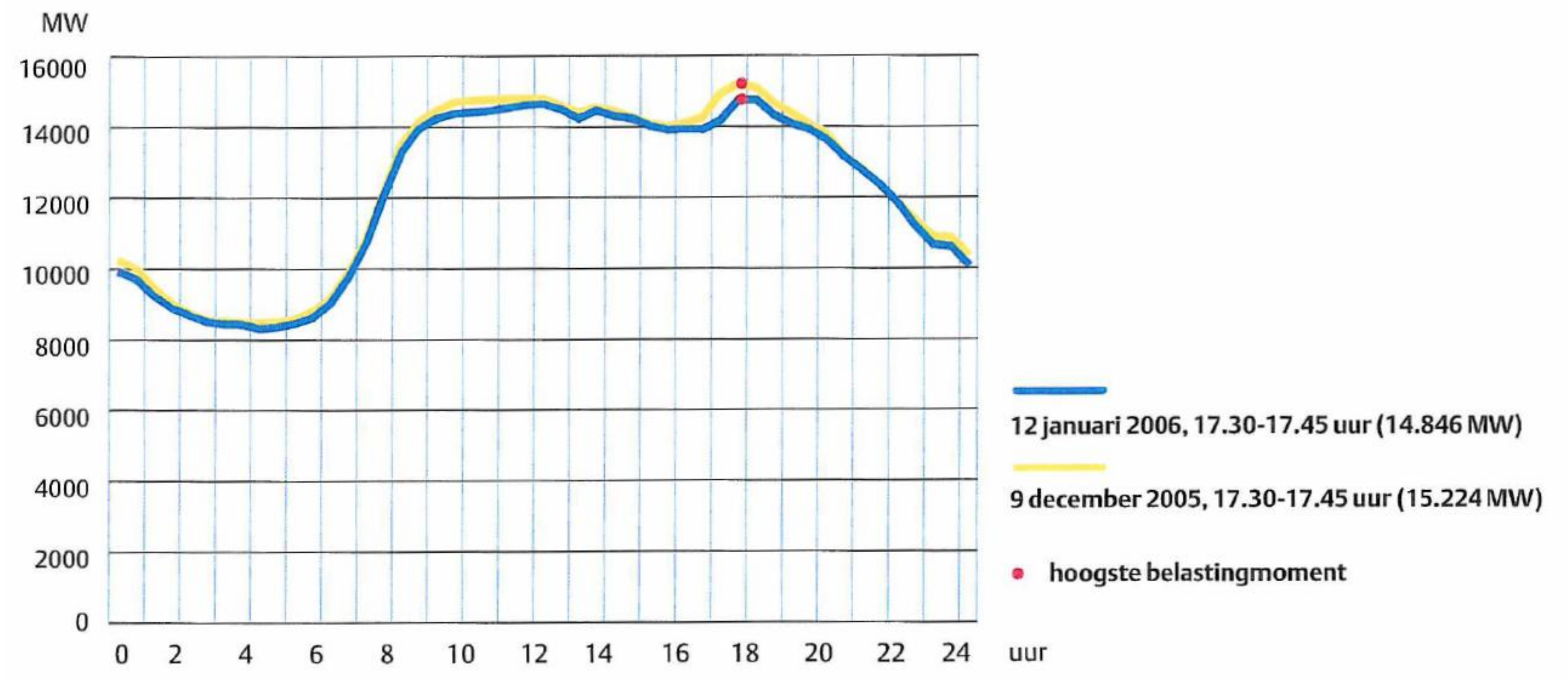
Intermittent sources: 10 GW wind, realised and predicted



Simulated output for a week of 6000 MW offshore and 4000 MW onshore wind

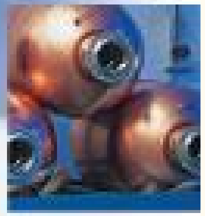
Differences between predicted and realised can be thousands of MW

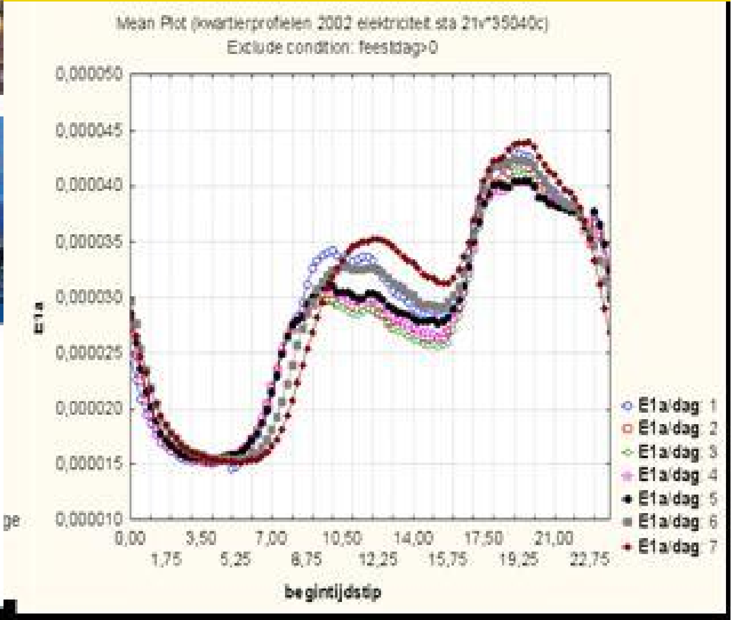
Day-night pattern total electricity demand in the Netherlands



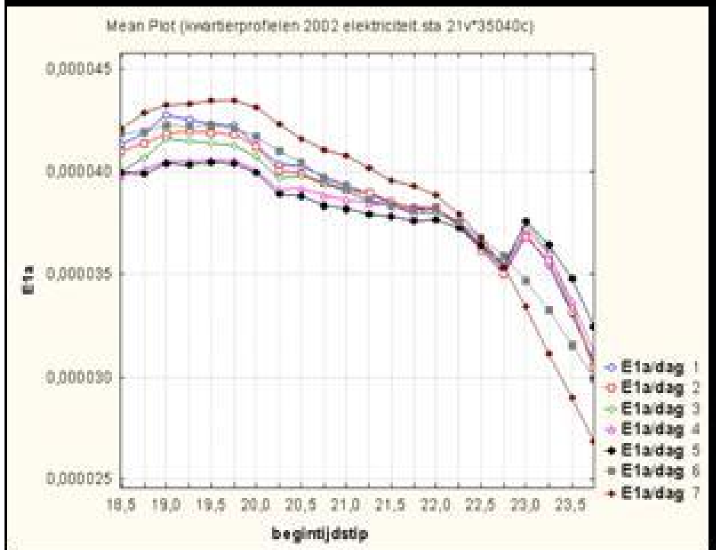
- Daily load pattern has a relatively high day-night difference compared to other European countries
- Interest from E-sector for additional electricity demand during the night hours

Residential electricity demand profiles





Top: residential demand profile 7 days, 24 hours



Bottom: same, but only in evening: note peak after 23h, when night tariff starts

Shifting demand to night tariffs affects a few % of residential electricity demand

Residential load shifting in the Netherlands

Currently:

- Mainly night storage boilers, dishwashers, washing machines and dryers
- Estimated load effected: a few % of annual residential electricity consumption

Electric appliances with a large future potential for load shifting:

- Plug-in hybrid electric vehicles
- Electric heat pumps
- Air conditioning

Increased need for flexibility in the electricity system

Additional flexibility can be provided by four main options:

1. Improve flexibility in conventional generation: higher ramp rates; improved partial load efficiencies; choice of generation mix
2. Stronger interconnections to average out variability of intermittent sources and to match it with a larger load
3. Integrate distributed generation in electricity markets (e.g. VPP with CHP units in horticulture)
4. Demand response

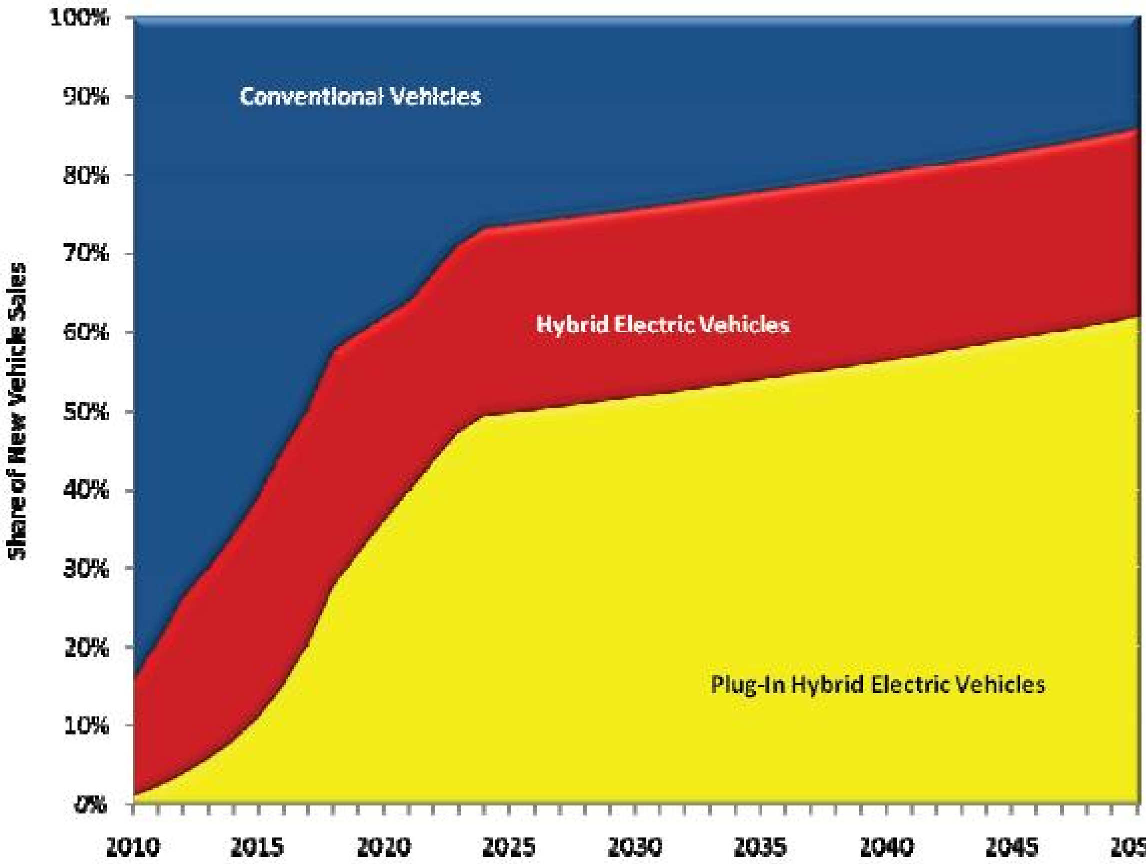
Netherlands energy agency SenterNovem funded **ITM Project** deals mainly with the demand response option and focusses on two technologies:

- Plug-in hybrid electric vehicles
- Residential electric heat pumps

PHEV and hybrid vehicle introduction scenarios from EPRI

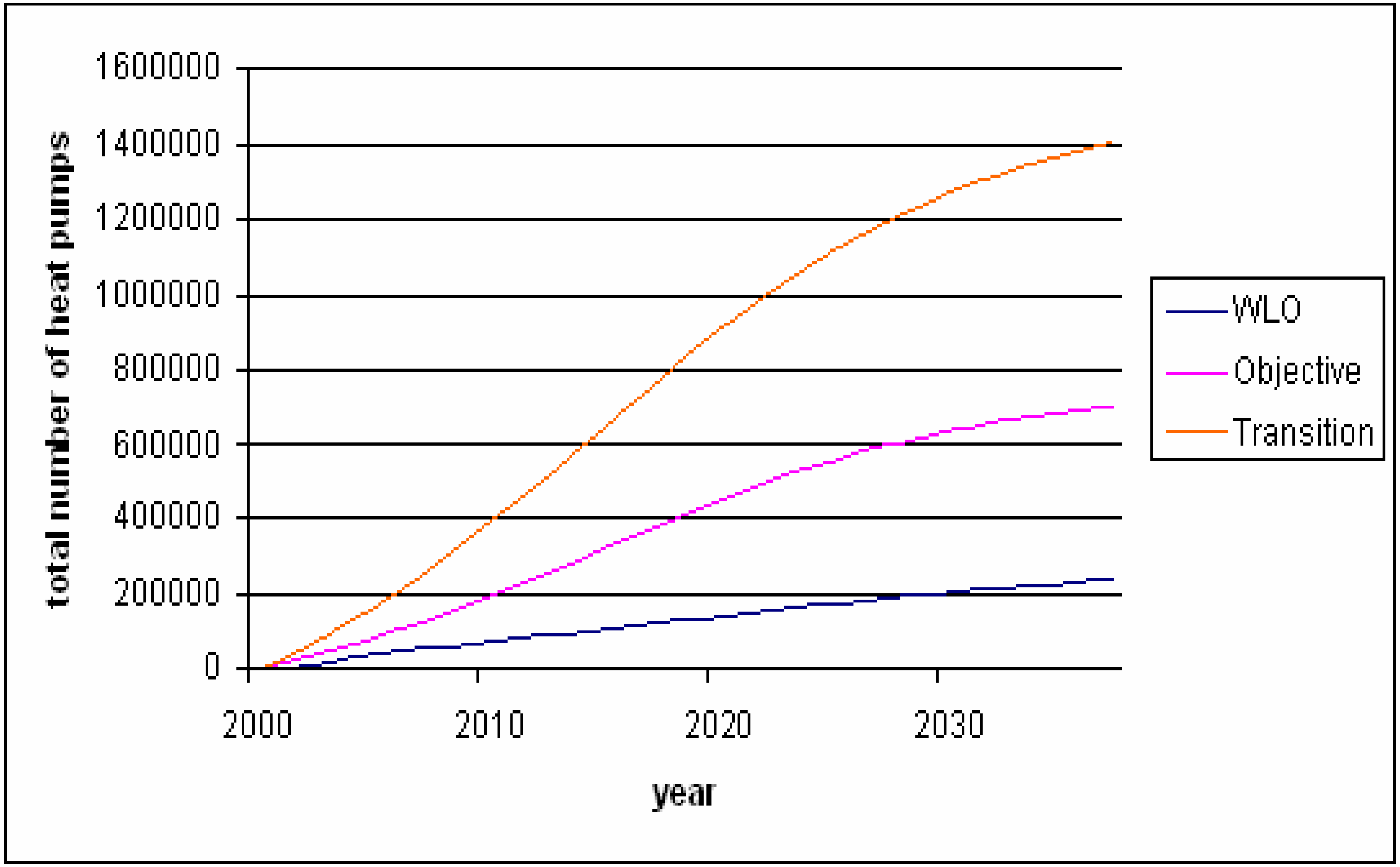
Peak new vehicle market share in 2050 for the three PHEV adoption scenarios

2050 New Vehicle Market Share by Scenario		Vehicle Type		
		Conventional	Hybrid	Plug-In Hybrid
PHEV Fleet Penetration Scenario	Low PHEV Fleet Penetration	56%	24%	20%
	Medium PHEV Fleet Penetration	14%	24%	62%
	High PHEV Fleet Penetration	5%	15%	80%



Assumed new car market share for the Medium PHEV scenario for conventional vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles for each vehicle category

Heat pump introduction scenarios in the Netherlands



Summary PHEV and heat pump scenarios in the Netherlands

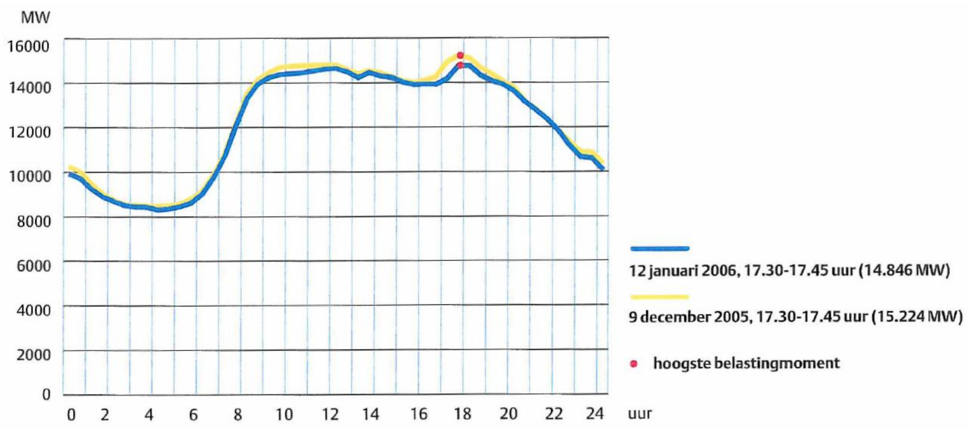
Table 8. Summary of plug-in vehicle and heat pump scenarios

	2020	2040
Plug-in vehicles:		
#Plug-in vehicles (millions)	0.9	6.5
Total charging capacity @3kW: (GW)	2.7	6.5
Annual electricity demand (TWh/a)	2.6	19.0
Electric Heat pumps:		
# heat pumps (millions)	0.9	1.5
Total installed capacity @3kW: (GW)	2.7	4.5
Annual electricity demand (TWh/a)	3.2	5.3

Contribution of PHEV and heat pumps to flatten day-night patterns

Table 9. Share of plug-in vehicle and heat pump electricity demand as percentage of final electricity demand in SE scenario, and their contribution to filling the 'night trough'

	2020	2040
Final electricity demand in SE scenario (TWh/a)	137	161
Electricity demand heat pumps + EV (TWh/a)	5.8	24.3
Heat pumps and EV as percentage of SE: (%)	4.2	15.1
Annual electricity demand to create a flat load curve (at load factor of 0.8) (TWh/a)	27	32
Heat pump and EV contribution to a flat load curve (%)	21	76



***Conclusion:** if heat pumps and electric vehicles become popular, residential load shifting can almost completely flatten the total electricity load in the Netherlands*

Quantifying flexibility in case of residential heat pumps (1 kW) with a simple building model

Daily averages	Turning off all heat pumps = P_{flex} upward	Turning on all heat pumps = P_{flex} downward	Max duration Pflex upward	Max duration Pflex downward	E_{flex}	Max shift in time of Eflex
	kW	kW	h	h	kWh	h
Average summer day	0.08	0.92	3.67	0.32	0.29	3.67
Average winter day	0.26	0.74	6.40	2.28	1.68	7.79
Coldest winter day	0.69	0.31	2.45	5.36	1.68	1.78
Annual average	0.17	0.83	5.77	1.19	0.99	

PRELIMINARY CONCLUSIONS ITM PROJECT:

- 1.5 million heat pumps (2040) can provide the equivalent of 250 MW regulating power and 1.5 GWh storage
- 6.5 million PHEV can provide 26 GWh of storage
- Together this is sufficient to compensate most of the short term differences between predicted versus realised output of 10 GW wind farms

Residential load shifting (with plug-in hybrid electric vehicles and heat pumps) can contribute substantially to integration of intermittent renewables