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‘Using home generated solar power for electric vehicles – user perspective.’

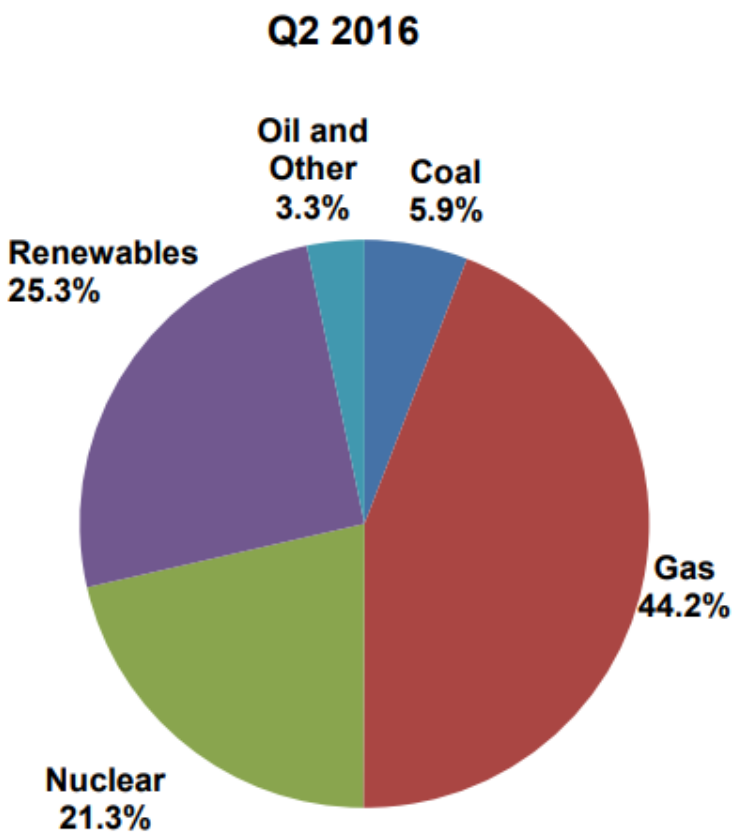
*BEng (Hons)

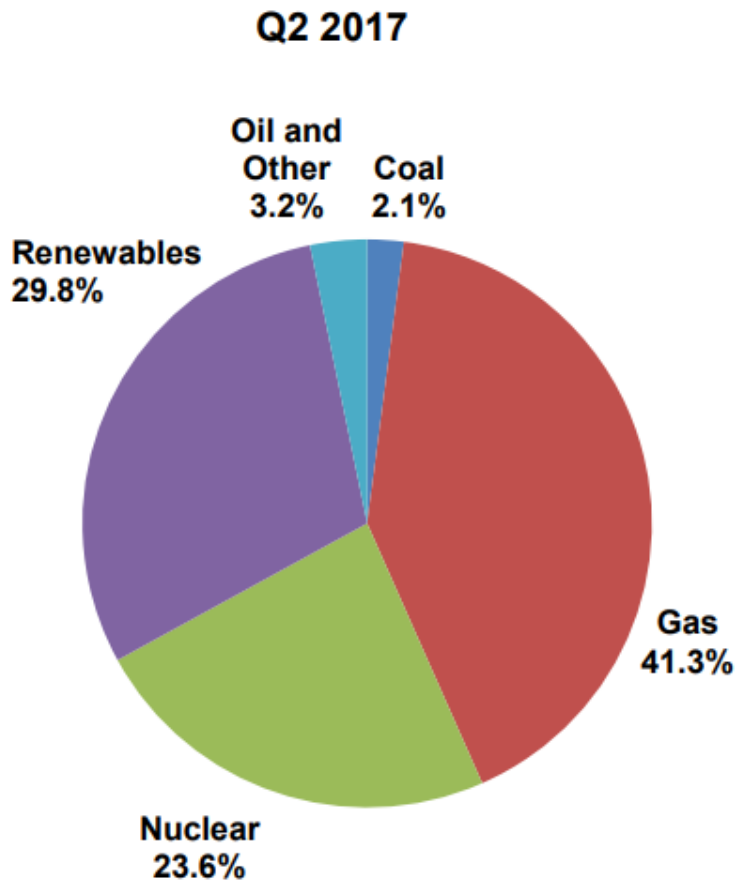
Aims and objectives

Compare energy profile for an ICE with an EV (Renault Zoe) for a family home in Edinburgh, which has a roof-mounted 2.88kWp solar array.

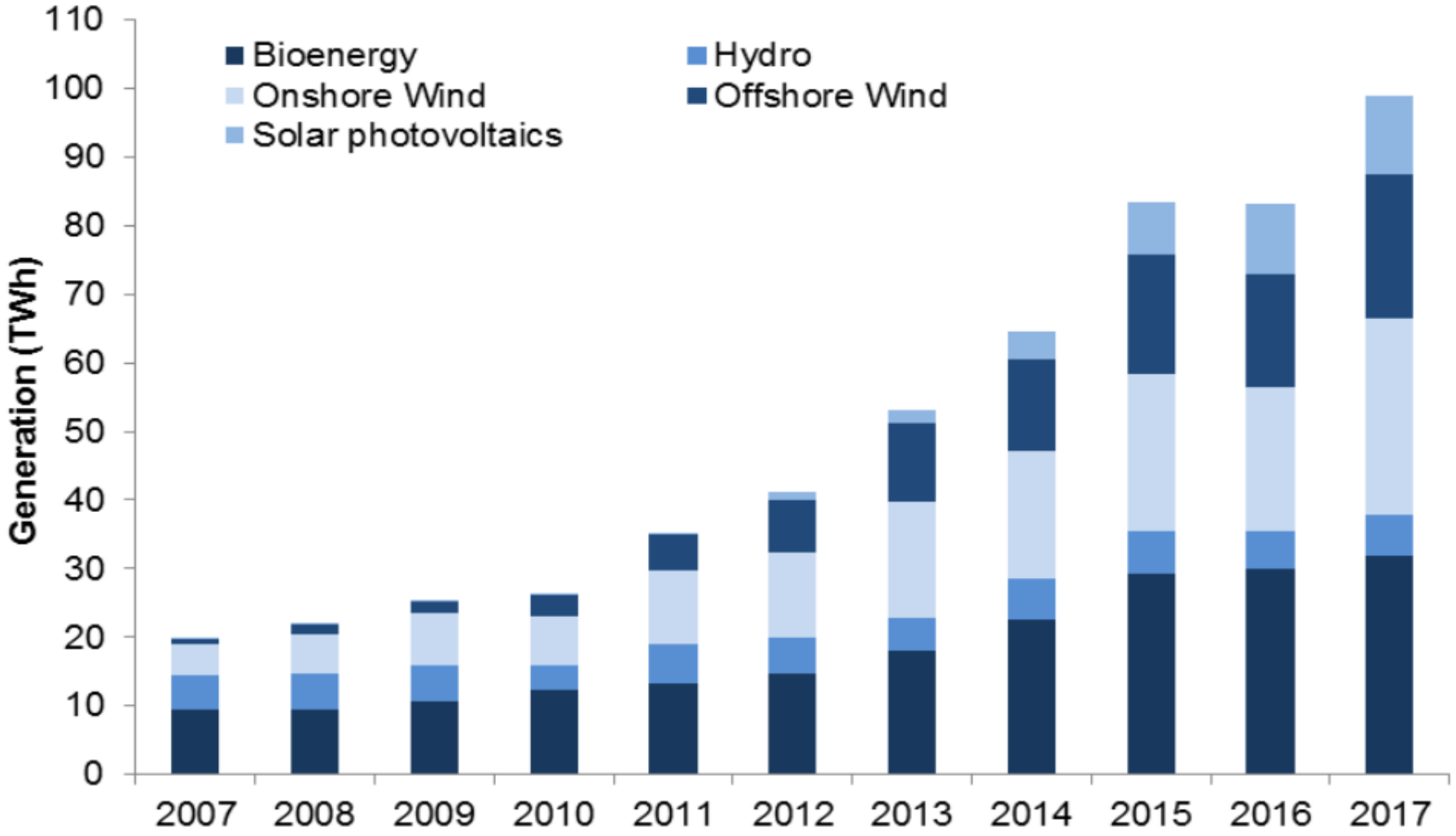
- Compare the recorded data from the solar modules to that calculated using software (Muneer, 2000)
- Compare the actual energy consumption of the EV to that which is calculated using Napier's VEDEC software model for traction and regenerative energy.
- Compare the cost benefit of using the Renault Zoe instead of the current ICE (Hyundai i30)

Energy generation breakdown for UK



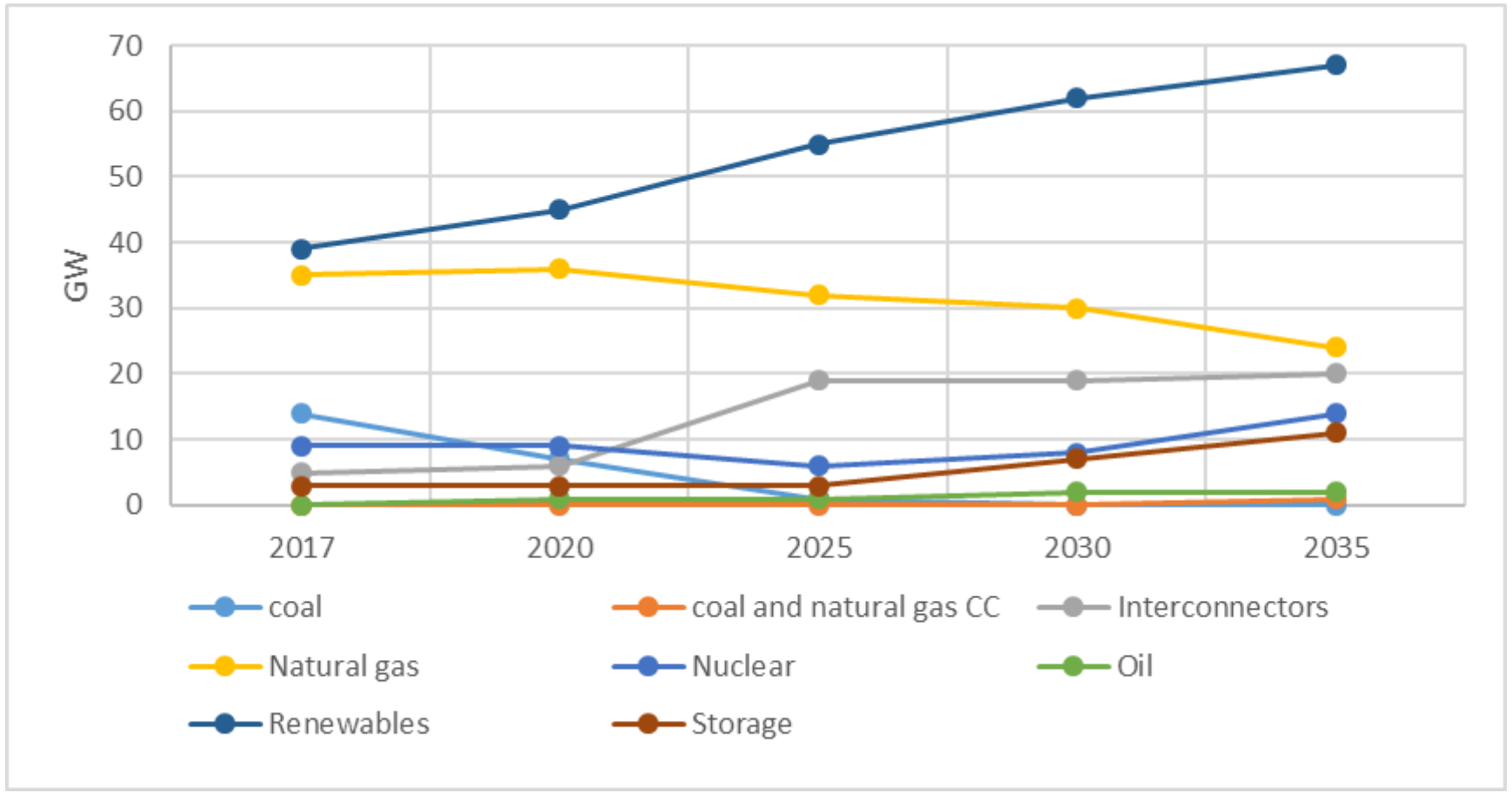


Renewable energy generation breakdown for UK



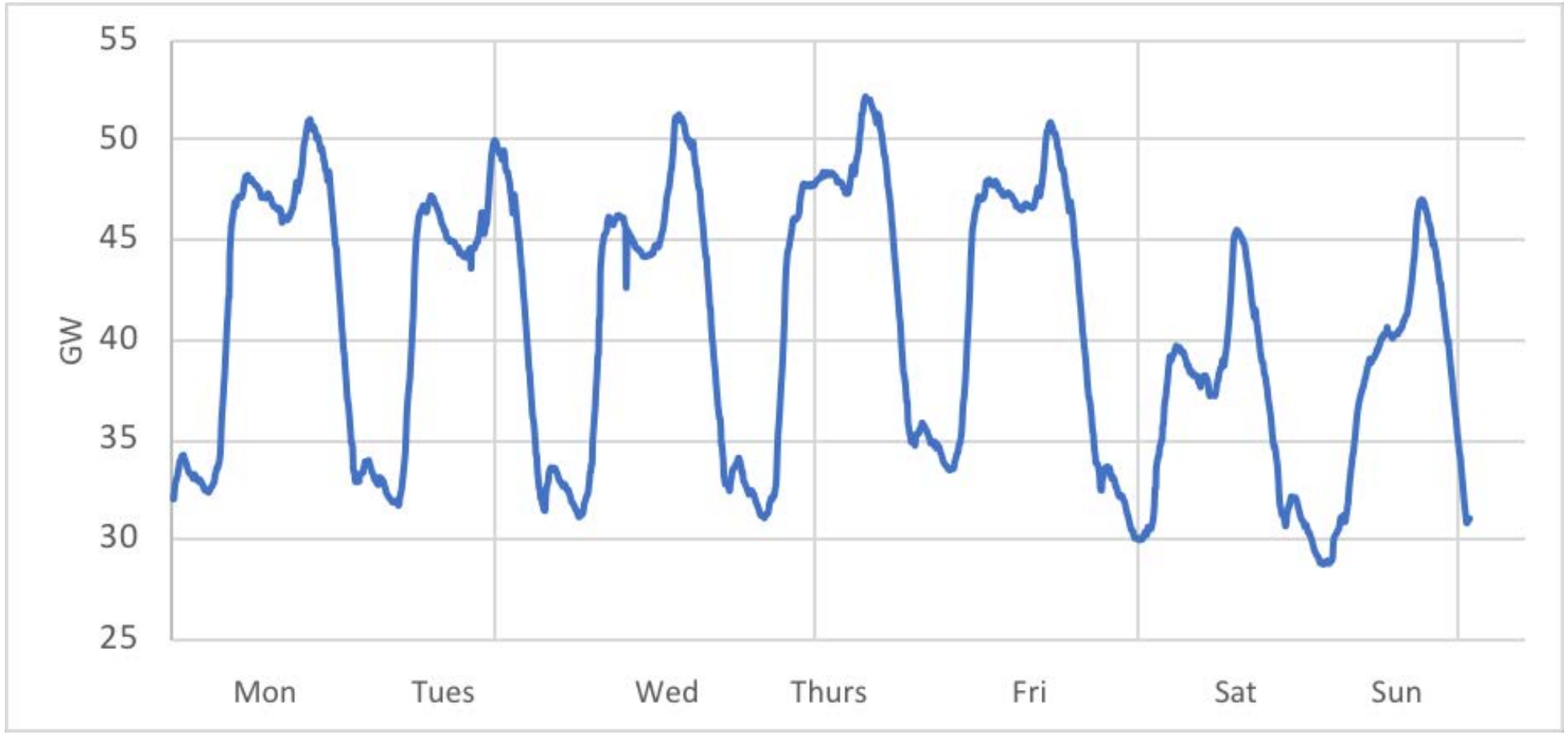
(Department for Business, Energy & Industrial strategy, 2018) UK Energy Statistics, Statistical Press Release

Energy generation projections (Statista,2018)



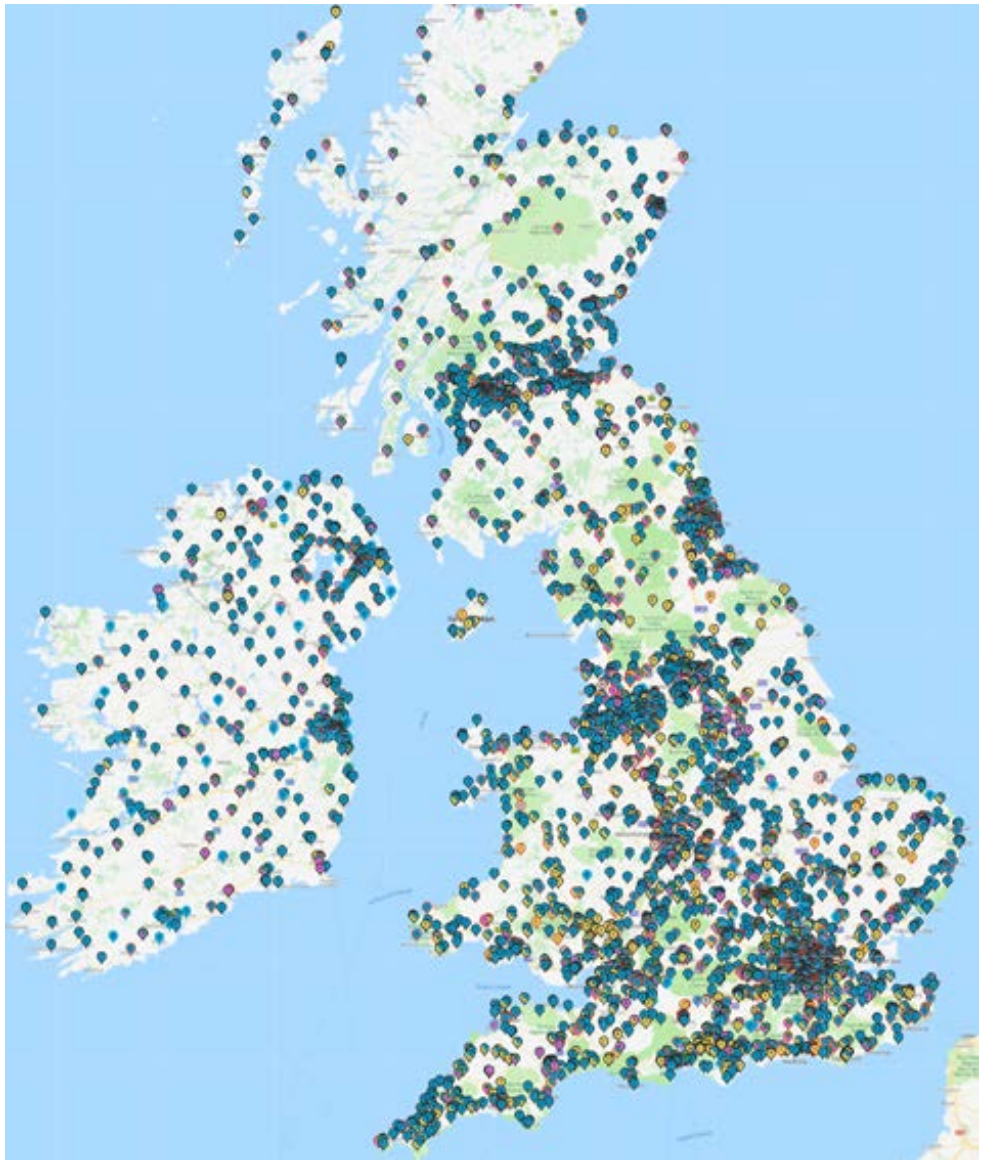
https://www.statista.com/statistics/496283/total-electricity-generation- capacity-uk/

Electricity demand profile of the UK (January 23rd -30th 2018)(Gridwatch)



http://www.gridwatch.templar.co.uk/

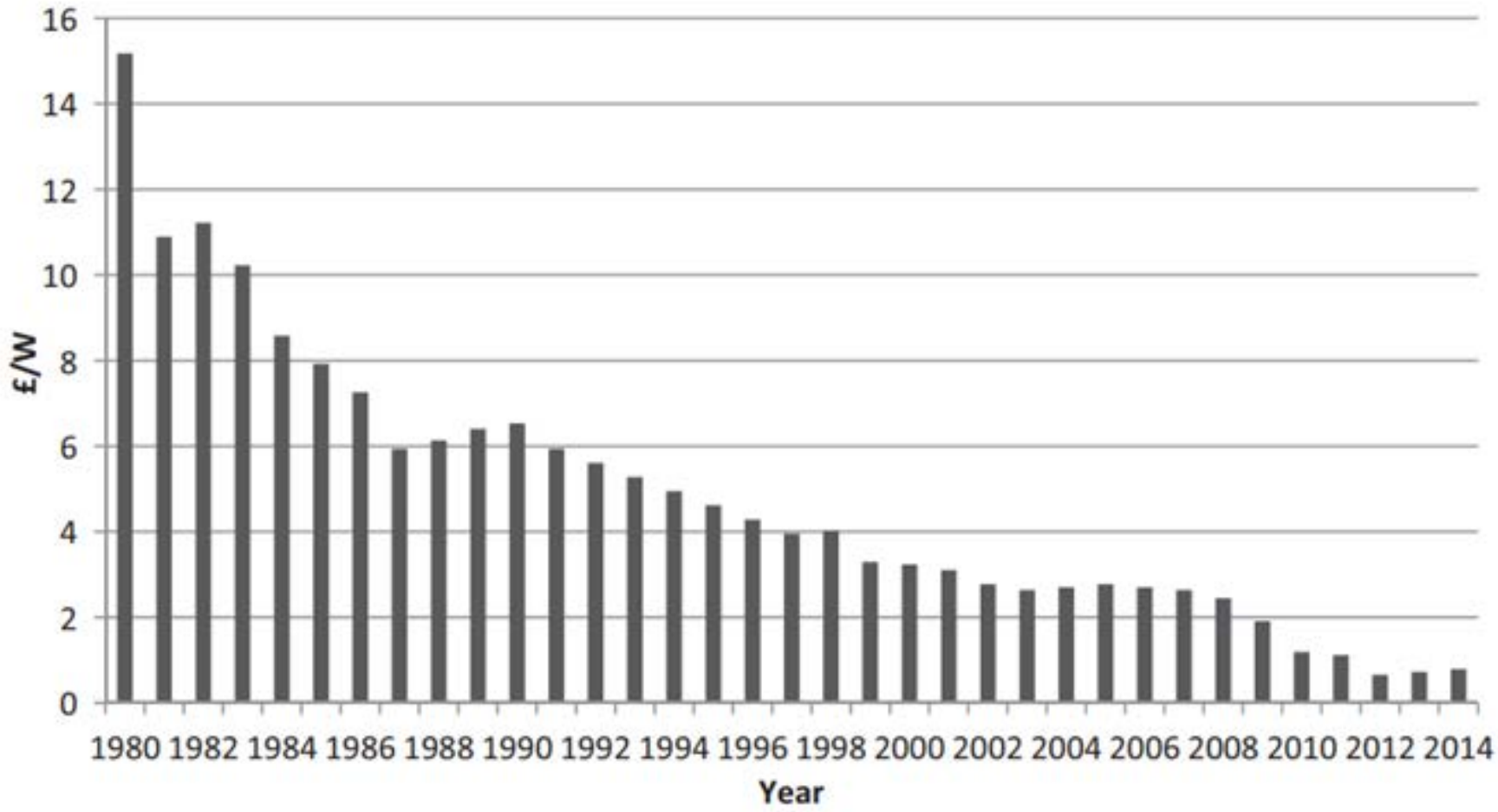
Charging network Zap-map (May, 2018)



- 16253 connectors
- 5659 locations
- 3406 rapid connectors

https://www.zap-map.com/

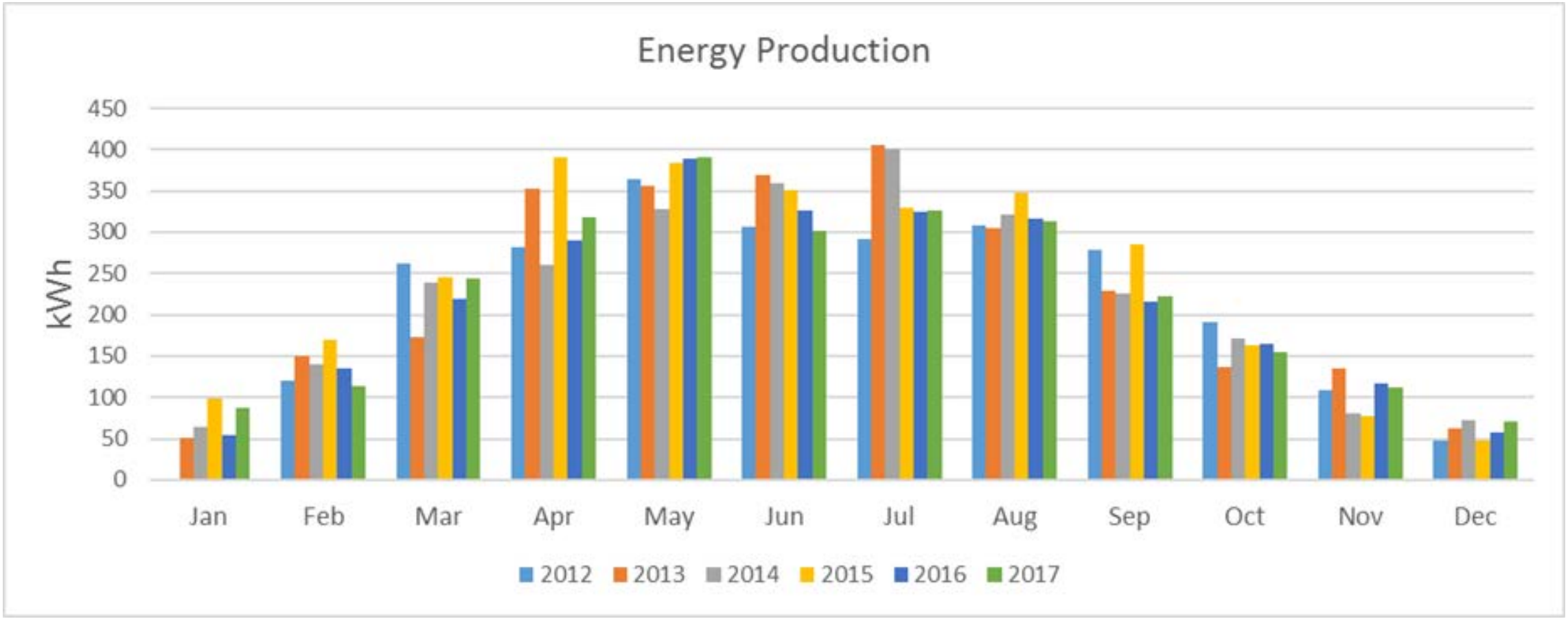
Solar PV price trend (Muneer et al, 2016)



2.88kWp M-C, PV array installed in February 2012

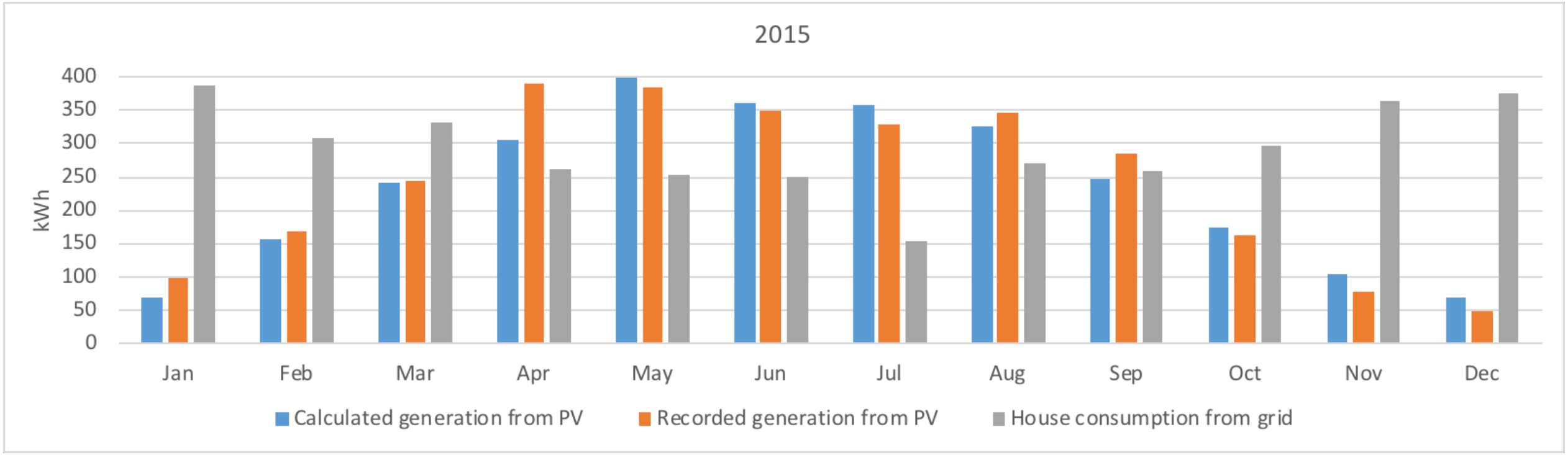
Author’s house located in ‘Newhaven’, Edinburgh

Energy production for ’Newhaven’ house (February 2012 – December 2017)



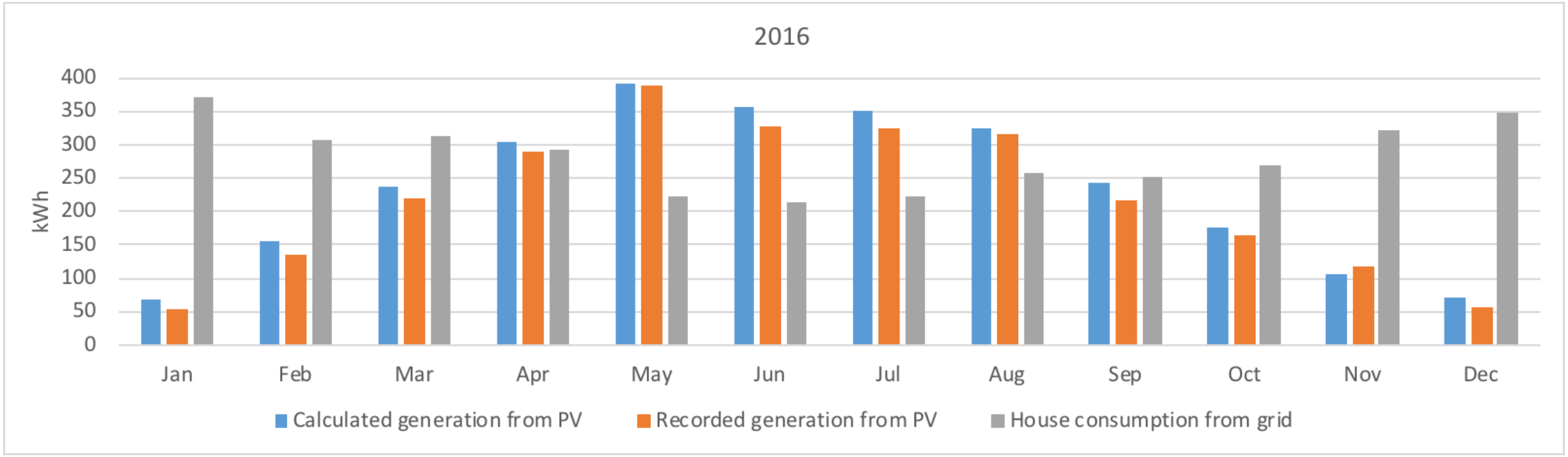
- Solar generation for PV **7.4 kWh/day**
- Demand for EV **2.3 kWh/day**

Energy generation and usage for ’Newhaven’ house



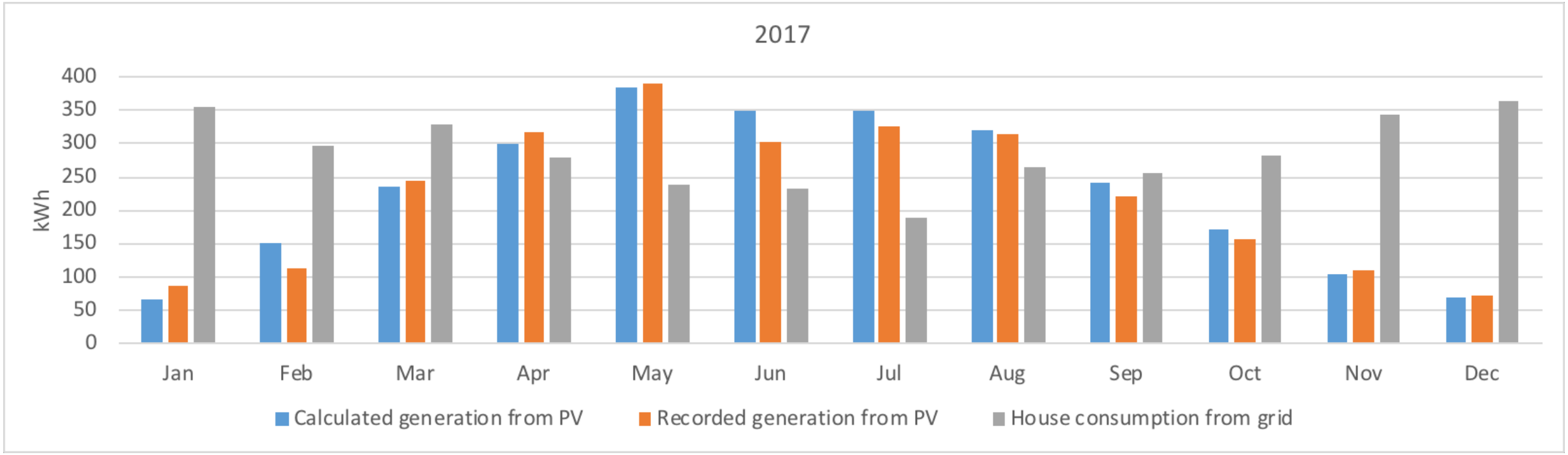
Software provides annual generation values with **2.7%** error of the recorded values

Energy generation and usage for ’Newhaven’ house



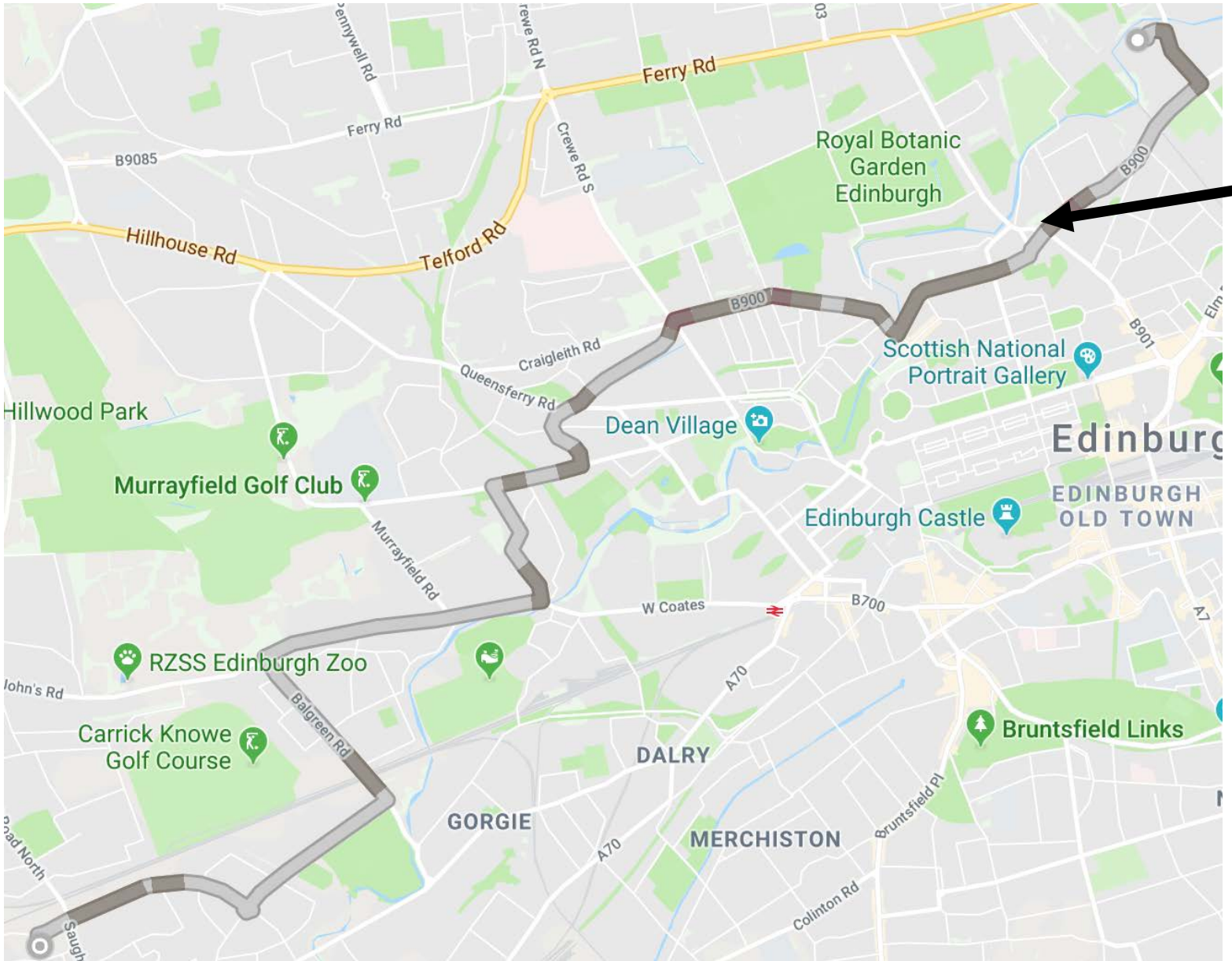
Software provides annual generation values with **6.7%** error of the recorded values

Energy generation and usage for ’Newhaven’ house



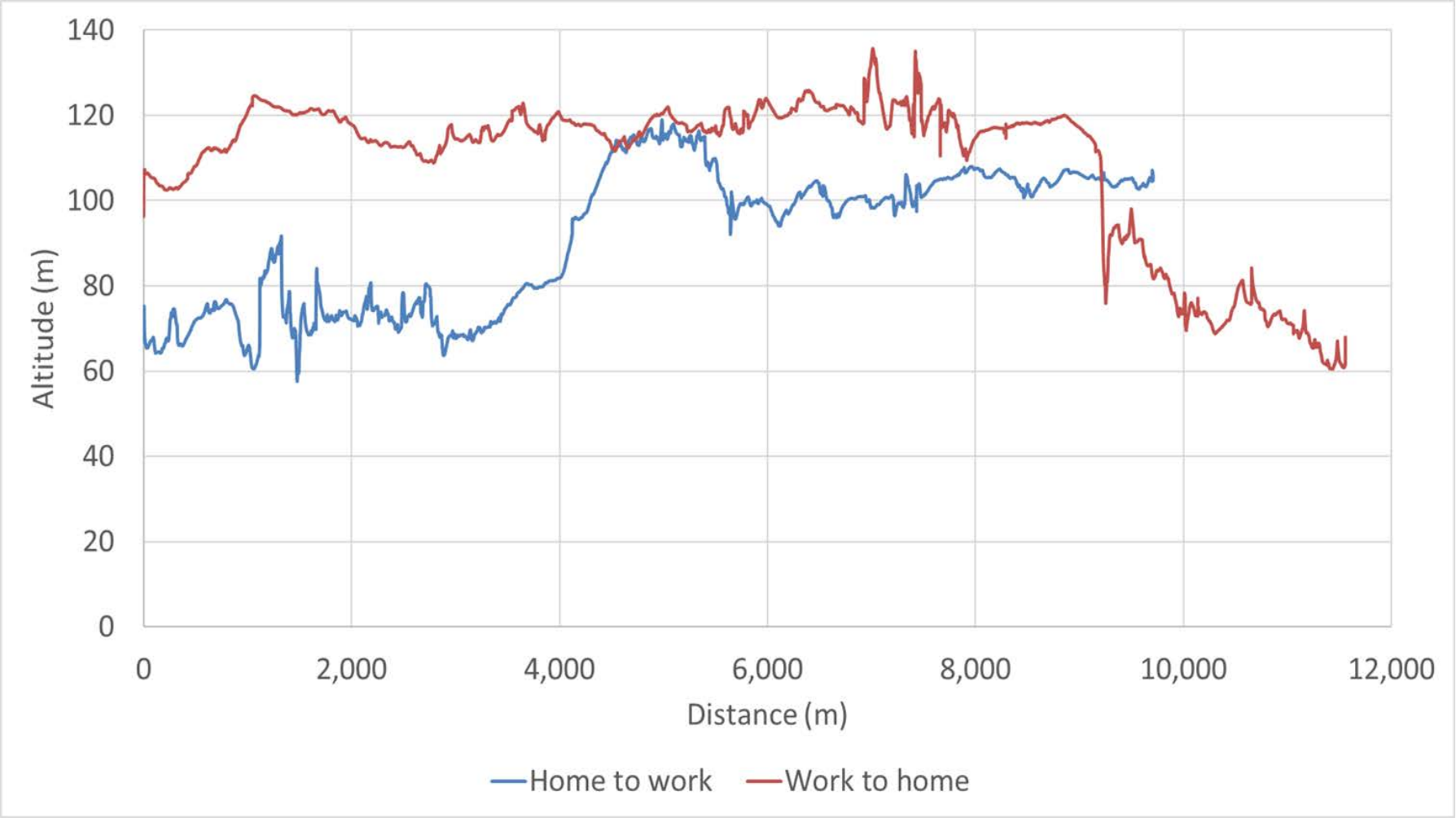
Software provides annual generation values with **3.4%** error of the recorded values

Home to work route



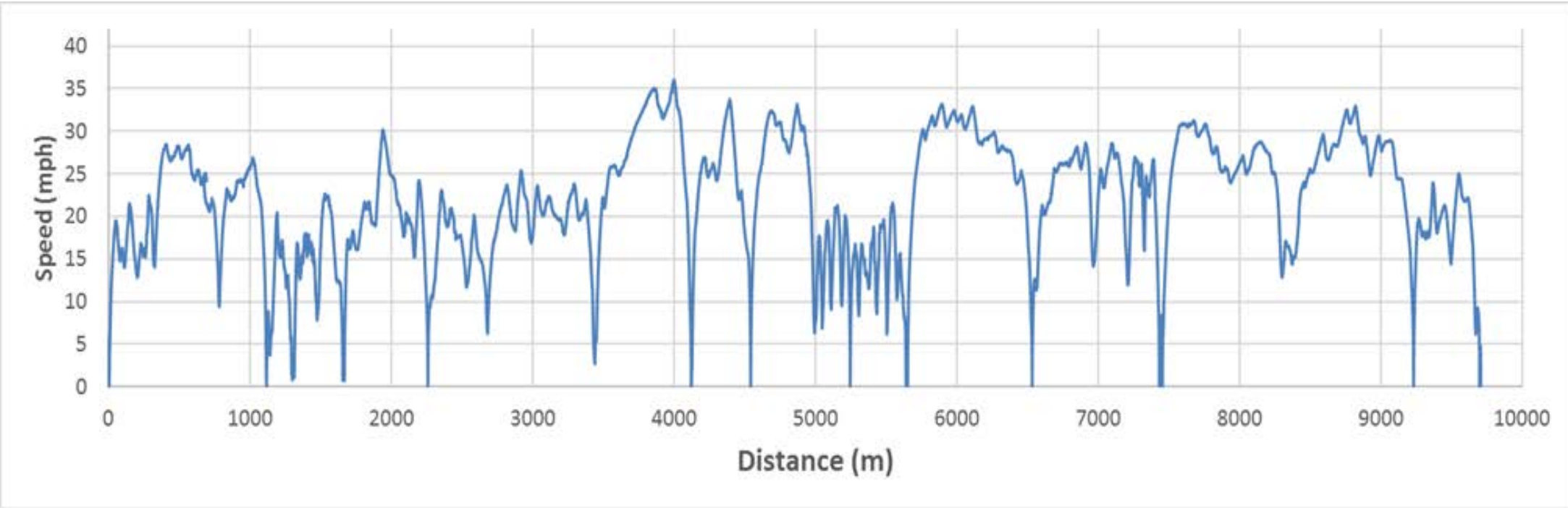
- Energy used 1.5 kWh for trip
- The return journey 1.3 kWh
- A return journey from supermarket 0.4 kWh
- Weekly usage assumes 5 return trips to work and the supermarket with weekly consumption of **16 kWh**

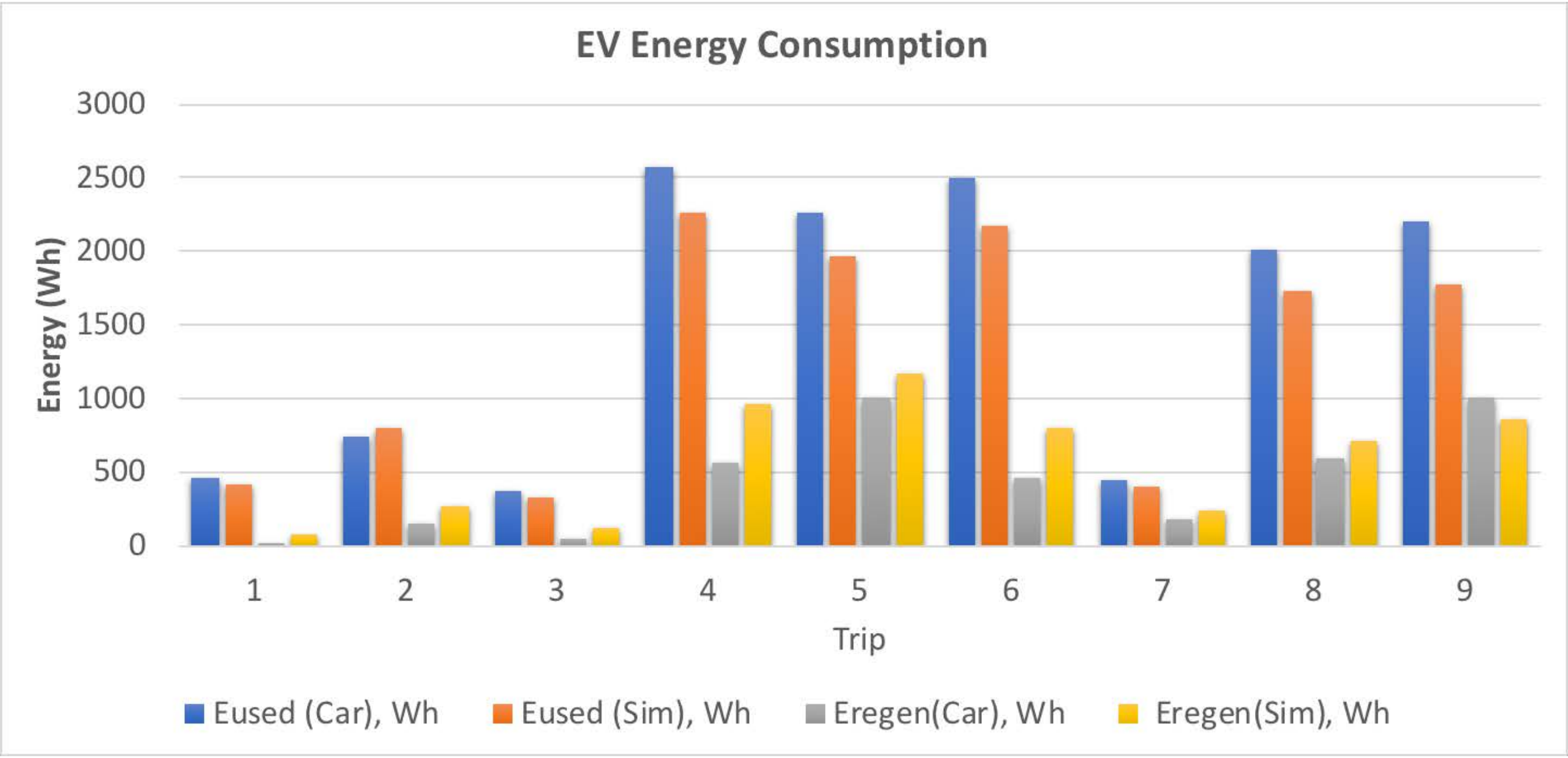
Data distribution for routes from the ’Newhaven’ home



- Data recorded using Racelogic drift box mini data logger, in conjunction with a gps antenna which is placed outside of the vehicle
- Data measured at frequency of 10 Hz

Speed profile for ’Newhaven’ house: Home to work

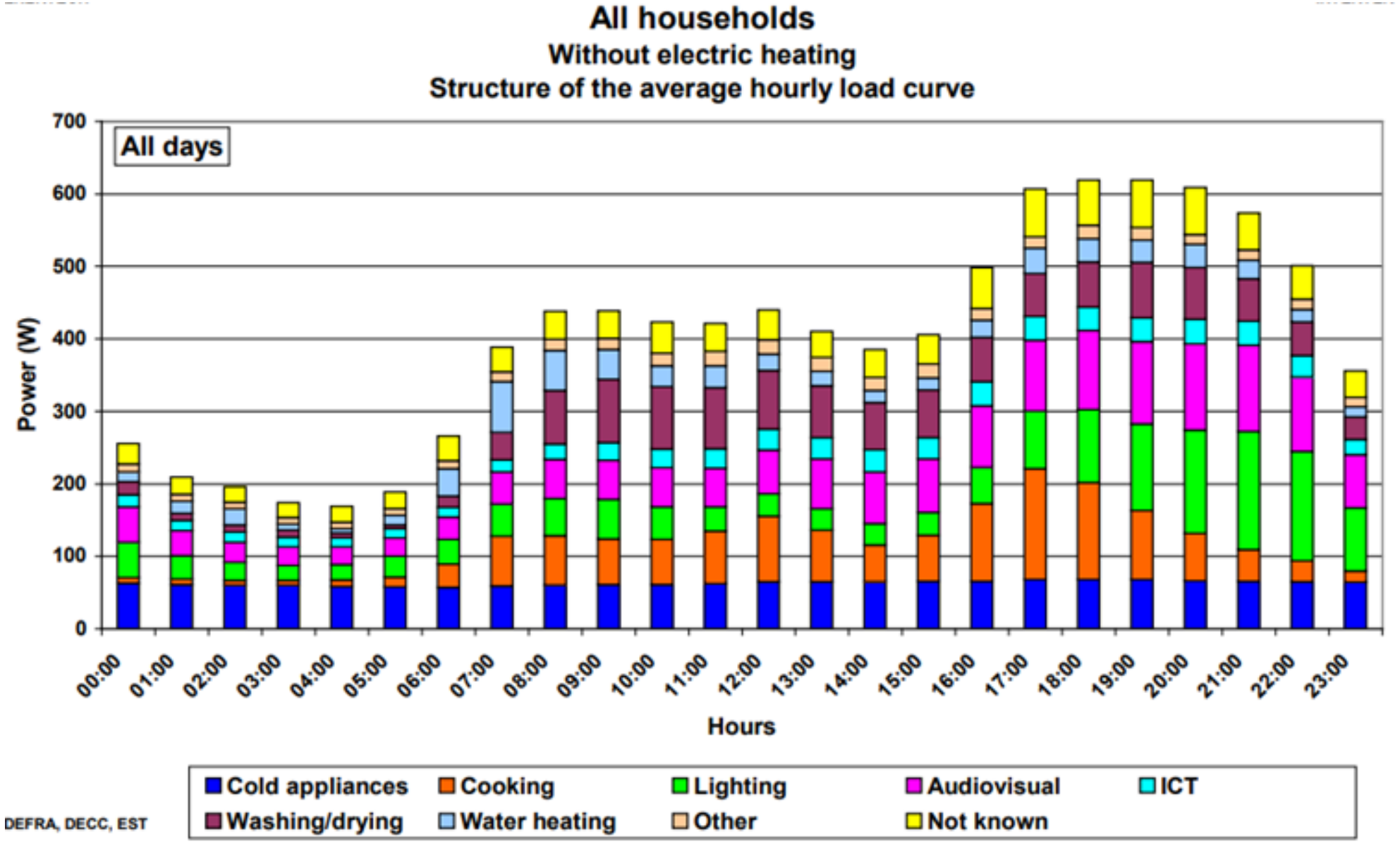



EV Energy Consumption
3000
2500
2000
1500
1000
500
0
Energy (Wh)
1
2
3
4
5
6
7
8
9
Trip
Eused (Car), Wh
Eused (Sim), Wh
Eregen(Car), Wh
Eregen(Sim), Wh

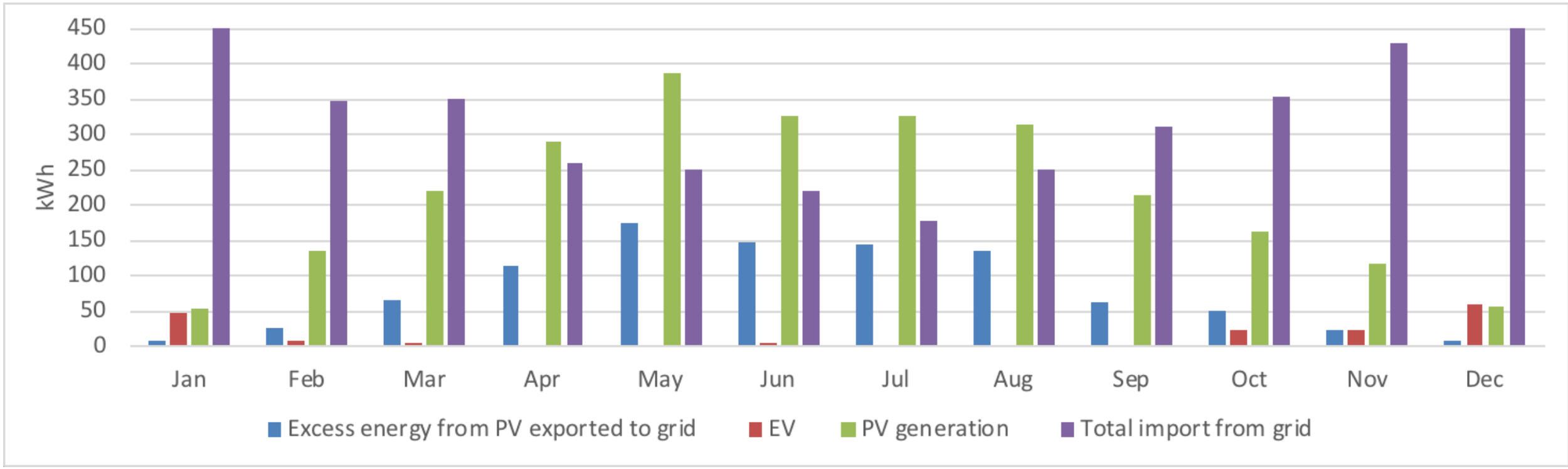
Energy consumption calculated

Trip	kWh/km	
	Recorded	Simulation
1	0.352	0.273
2	0.252	0.225
3	0.191	0.121
4	0.180	0.117
5	0.179	0.113
6	0.326	0.221
7	0.154	0.089
8	0.155	0.105
9	0.114	0.080
Average	**0.217**	**0.146**

Hourly household energy demand (Intertek, 2012)



Energy audit for ’Newhaven’ house for year 2017



Solar Energy Economics

- Installation cost of solar array **£7,402.50**
- Average energy generation over the last 5 years is **2706kWh**
- Assuming a life span of 25 years and an average yearly generation of 2706kWh
    - The cost per kWh is **10.94p/kWh**
- With the solar panels resulting in an average annual income of **£1,341**
- **49.56p/kWh**
- With an net income of **38.62p/kWh**
- Net cost per kWh with new FIT is **4.62p/kWh**

Current FIT for 'Newhaven' installation
Generation 50.67p/kWh
Export 3.57p/kWh

Current FIT for new homes
Generation 3.85p/kWh
Export 5.03p/kWh

Economics

Automobile related

- The current ICE (Hyundai i30), fuel costs **£477**
- If EV was run from solely the grid, **£102**
- If EV uses solar when available **£50**

Overall – FIT for ‘Newhaven’

- No Solar & ICE: **£1,054**
- No Solar & EV: **£679**
- Solar & ICE: ***£490 earning***
- Solar & EV: ***£821 earning***

Overall – current FIT

- Solar & ICE: **£710**
- Solar & EV: **£380**

Annual Carbon-dioxide emission

Automobile related

- ICE: **1081 kgCO_2**
- Grid-powered EV: **292 kgCO_2**
- Solar-powered EV: **81 kgCO_2**

’Newhaven’ House related

- Solar with ICE: **1212 kgCO_2**
- Solar with EV: **1355 kgCO_2**

Total emissions

- Solar with ICE: **2293 kgCO_2**
- Solar with EV: **1435 kgCO_2**

Calculated using

- 0.35156 kgCO_2/kWh from the grid *
- 0.044 kgCO_2/kWh from solar **

*Final UK greenhouse gas emissions national statistics, 2017

** (Muneer et al, 2015)

Thank you

Any Questions?

References

T. Muneer, N. Abodahab, G. Weir and J. Kubie, Windows in buildings : thermal, acoustic, visual and solar performance, Oxford : Architectural Press, 2000.

Department for Business, Energy & Industrial Strategy, “UK Energy Statistics, Q2 2017,” 28 September 2017. [Online]. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/647750/Press_Notice_September_2017.pdf. [Accessed 30 September 2017].

M. Gul, Y. Kotak and T. Muneer, “Review on recent trend of solar photovoltaic technology,” *Energy Exploration & Exploitation,* p. 508, 2016.

Intertek - J.P. Zimmermann, M. Evans, J. Griggs, N. King, L. Harding, P. Roberts and C. Evans, “Household Electricity Survey A study of domestic electrical product usage,” May 2012

T. Muneer, R. Milligan, I. Smith, A. Doyle, M. Pozuelo and M. Knez, “Energetic, Environmental and Economic Performance of Electrical Vehicles : Experimental Evaluation,” Elsevier, Edinburgh, 2015.