

**energy
saving
trust**

The benefits and considerations
of heat pumps, PV, and batteries
– an integrated system

Green Heat Installer
Engagement Programme

13 September 2023



Presenters

Pilar Rodriguez	Programme Manager, Green Heat Installer Engagement Programme, Energy Saving Trust	Presenter, Q&A Panel
Ben Whittle	Senior Low Carbon Consultant, Energy Saving Trust	Presenter, Q&A Panel
Torin Clarke	Scottish Home Renewables, Energy Saving Trust	Presenter, Q&A Panel
David Stutchfield	Green Homes Network Member	Presenter, Q&A Panel

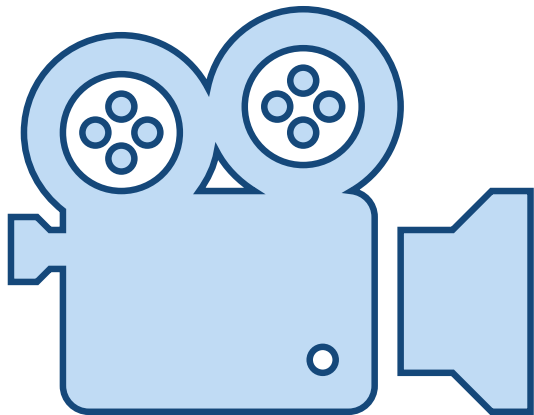
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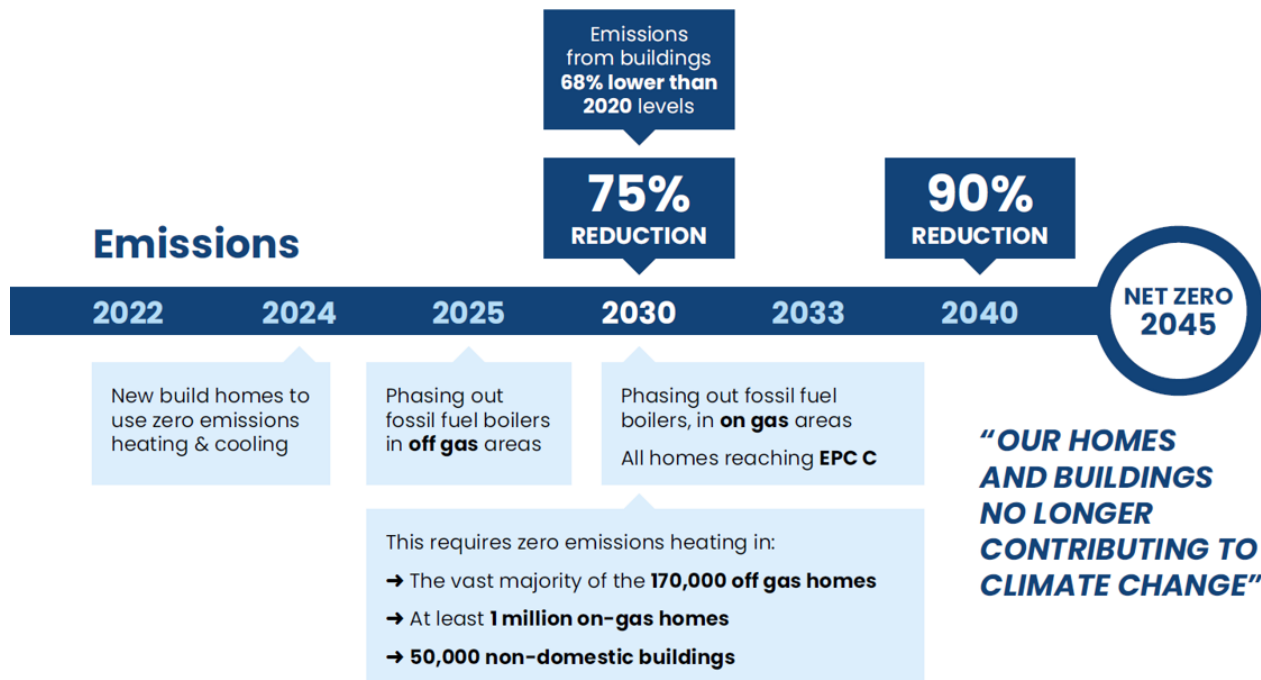
Integrated Systems

Role in decarbonising our homes

Pilar Rodriguez

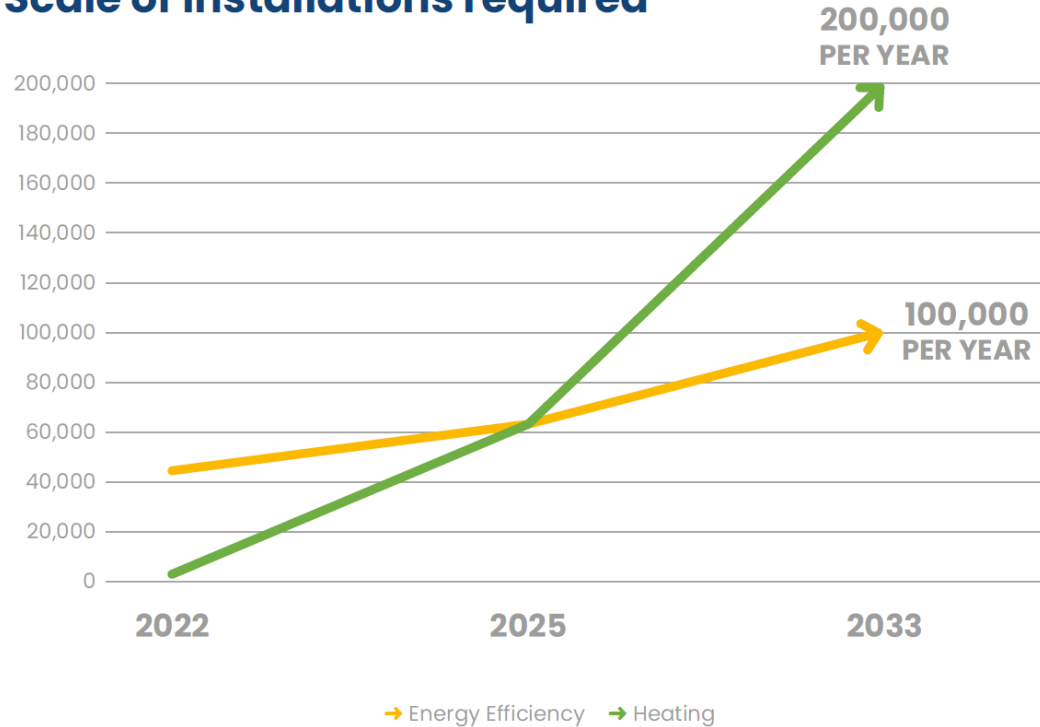


Scottish Government Heat in Buildings Strategy



Domestic energy efficiency installations

Scale of installations required



How are we going to get there

Low and Zero Emissions Heating Systems

Systems that have **zero direct greenhouse gas emissions** such as individual electric heat pumps and connection to heat networks, or electric systems such as storage heaters, and systems that have very low emissions such as those that use hydrogen.

No and low regrets strategic technologies

Energy efficiency

Heat pumps in off gas areas

Heat pumps in on gas areas

Low and zero emissions heat networks



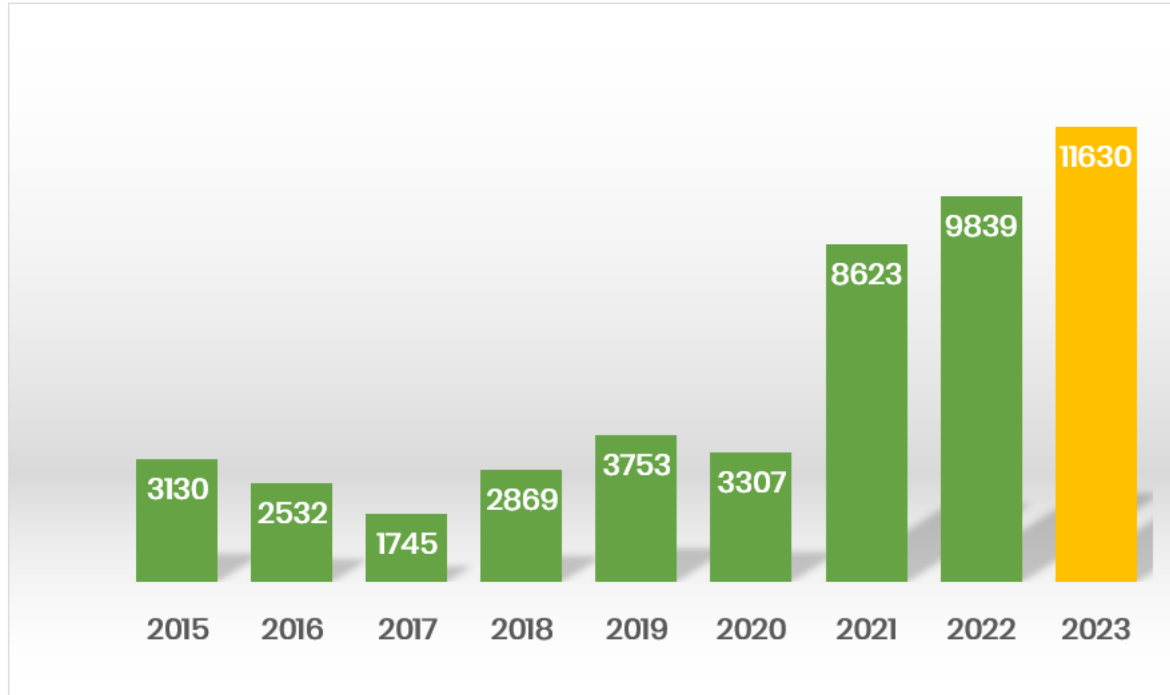
Electrification of heat and secondary technologies

Technologies that work well in conjunction with zero emissions heating systems:

- e.g. solar thermal, solar PV, and battery storage

Solar thermal can supplement the hot water supply and PV can contribute to electrical demand

Rooftop PV installations in Scotland



- **2015:** Major cut to FIT for small-scale installations
- **2019:** End of FIT scheme
- **2020:** Pandemic lockdown
- **2021:** Energy price crisis begins
- **2022:** Gas prices further up due to Russia's invasion of Ukraine

Source: mcs-certified.com/low-carbon-landscapes

Green Heat Installer Engagement Programme – useful links

- Website: energysavingtrust.org.uk/green-installer
- Email updates and quarterly newsletter subscription – bit.ly/2PSatkl
- LinkedIn group: linkedin.com/groups/5139242
- Email: GreenInstallerScotland@est.org.uk

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Thank you



Modelling Solar PV heat pumps and batteries

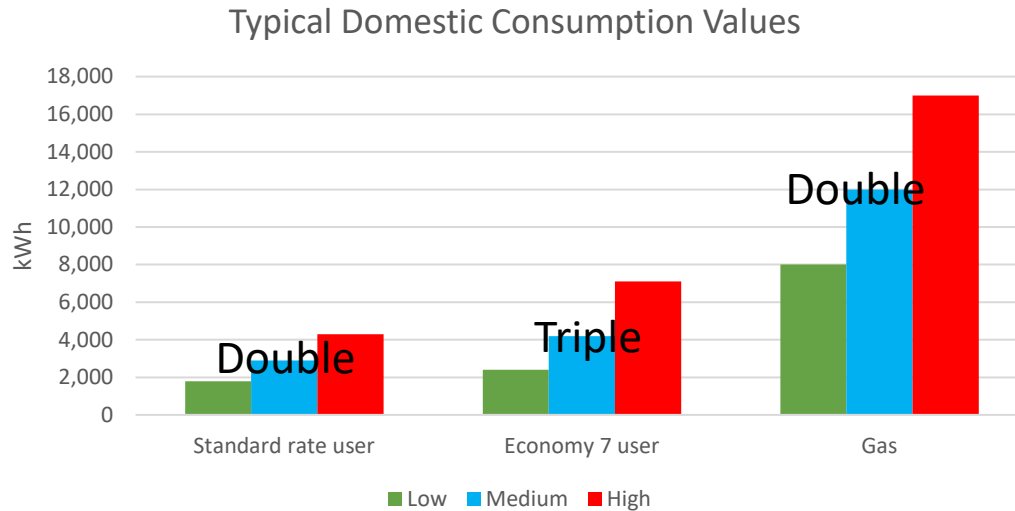




What do we mean by a “typical” house
What do we mean by “typical” energy use?
What are the ranges we might expect?

How much impact does solar have?
How much impact does a heat pump have?
How much can batteries help?
How much can smart tariffs help?

Typical domestic Consumption Values (electricity and gas)



	<i>kWh</i>	Current TDCVs	Revised TDCVs
Gas	Low	8,000	8,000
	Medium	12,000	12,000
	High	17,000	17,000
Electricity: Profile Class 1	Low	1,900	1,800
	Medium	3,100	2,900
	High	4,600	4,300
Electricity: Profile Class 2	Low	2,500	2,400
	Medium	4,200	4,200
	High	7,100	7,100

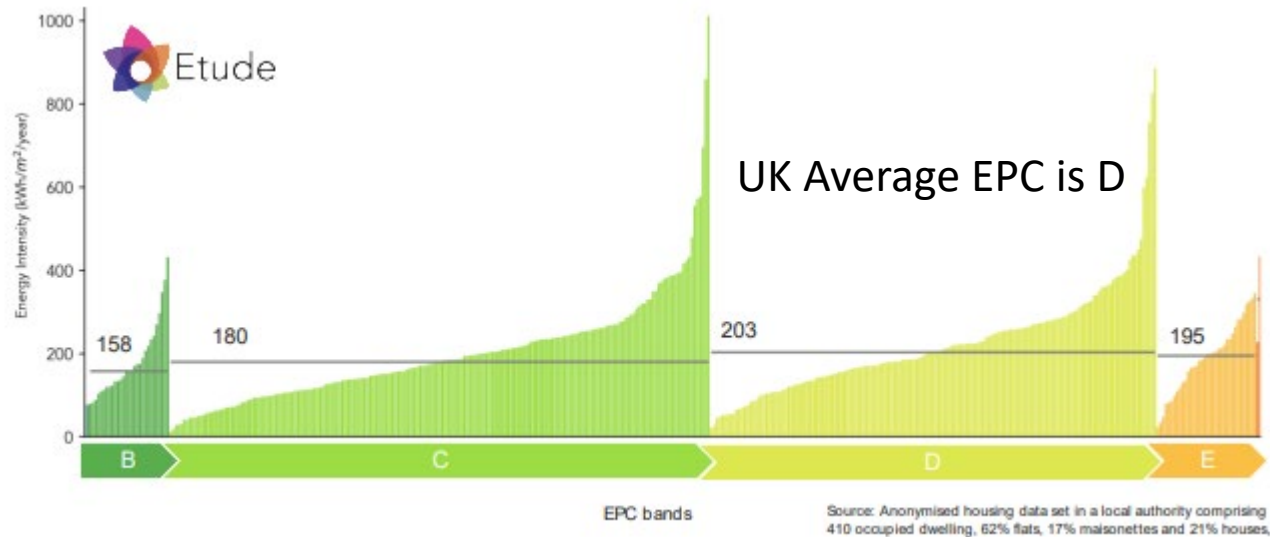
	2017 consumption split (GB)	2019 consumption split (GB)
Peak (day time usage)	58%	59%
Off-peak (night time usage)	42%	41%

Actual energy use depends on a lot of factors and can cover huge ranges depending on heating system type and efficiency etc

EPC bands don't help...

this chart is total energy use per sqm by EPC band (in 410 houses analysed).

EPC scores combine many metrics and aren't a straightforward representation of actual energy use





What we have learnt so far:

There is no such thing as a typical house
... or typical energy use

Housing Archetypes



How do we go about modelling renewables?



Created with PV* SOL premium 2019 (R10)
Valentin Software GmbH



PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM

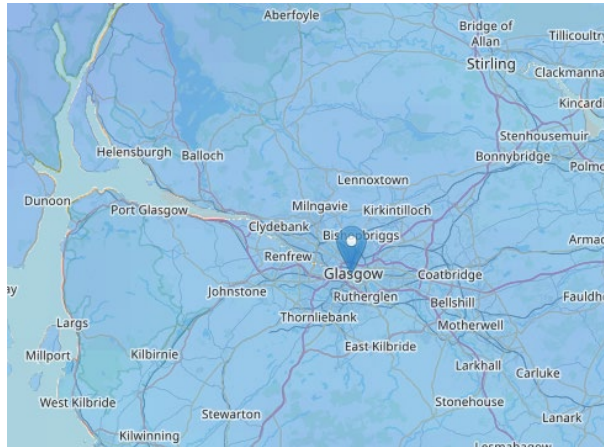
How do we go about modelling integrated systems?

1. Choose a location > get solar and climate information
2. Select system size > get amount of energy produced
3. Create a “grid” of electricity use and generation
4. Sum all the positive and negative amounts
5. Result > an energy system balance
> an idea of running costs

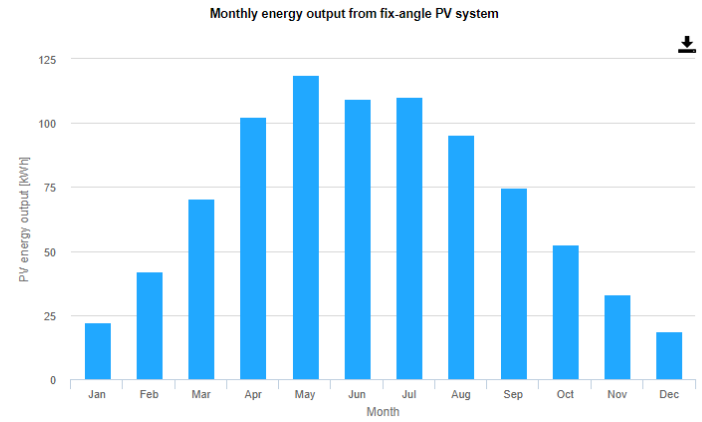
1. Choose location

> get climate information

PV-GIS is free, but only monthly data - Not very helpful for detailed models



Summary	
Provided inputs:	
Location [Lat/Lon]:	55.853,-4.248
Horizon:	Calculated
Database used:	PVGIS-SARAH2
PV technology:	Crystalline silicon
PV installed [kWp]:	1
System loss [%]:	14
Simulation outputs:	
Slope angle [°]:	35
Azimuth angle [°]:	0
Yearly PV energy production [kWh]:	850.46
Yearly in-plane irradiation [kWh/m ²]:	1052.11
Year-to-year variability [kWh]:	27.56
Changes in output due to:	
Angle of incidence [%]:	-3.32
Spectral effects [%]:	1.75
Temperature and low irradiance [%]:	-4.45
Total loss [%]:	-19.17

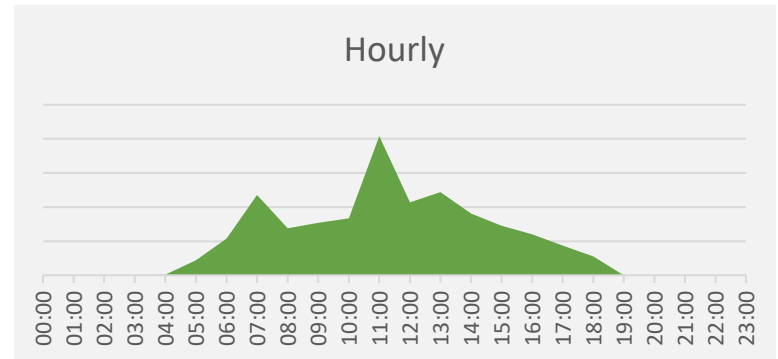
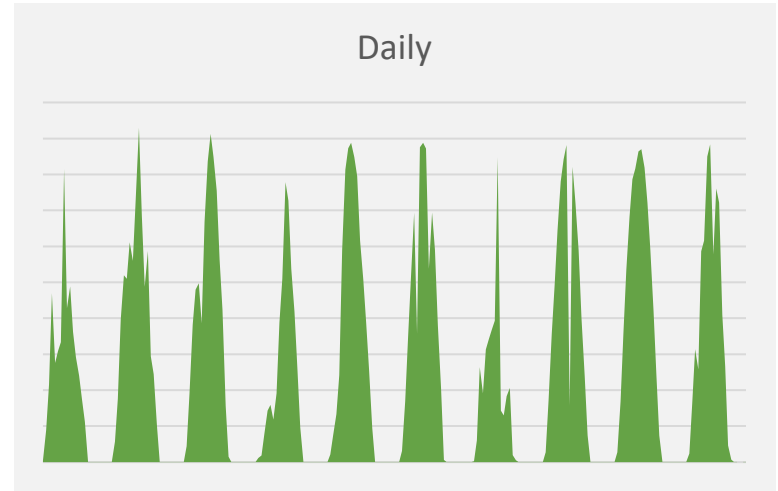


Paid for software –

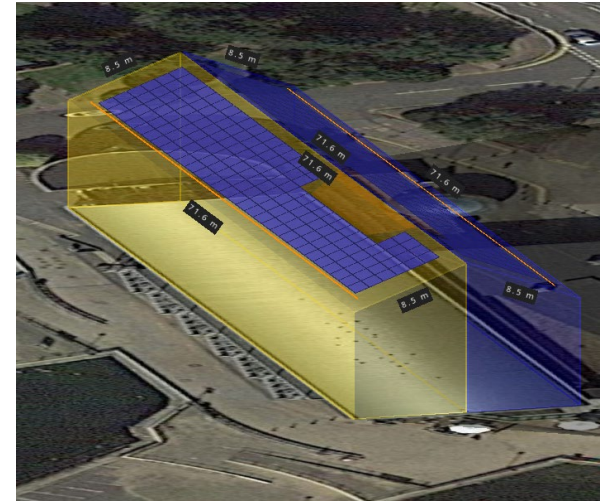
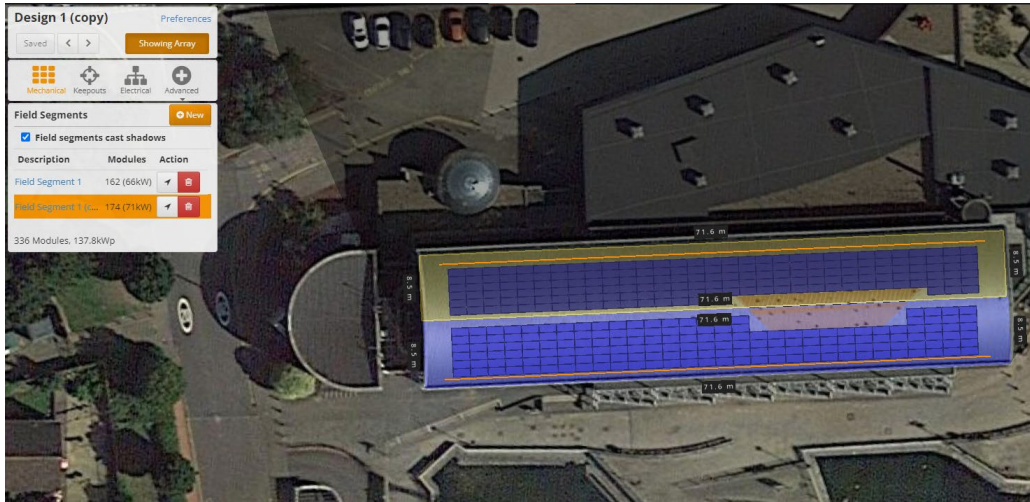
Hourly, 30min or even 5 minute results of typical solar insolation levels anywhere in the world using “TMY” models (Typical Meteorological Year).

An average of conditions across multi year ranges

Much more useful!



2. Select system size > get solar output



Areas are defined using aerial photography

Distances can be measured accurately to within about +/- 25cm



Creating the “Grid” of consumption and generation

1. Choose a location > get solar and climate information
2. Select system size > get amount of energy produced

3. Create a “grid” of electricity use and generation

4. Sum all the positive and negative amounts
5. Result > an energy system balance

Negative amounts

Lights, Fridge, cooking
Electric vehicle
Heat pump
Etc

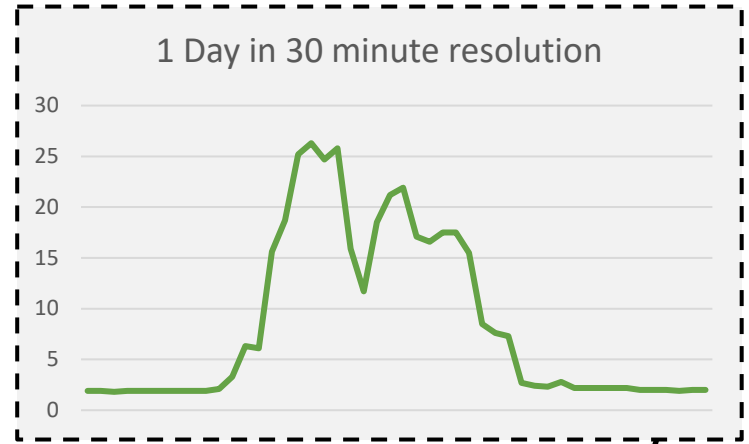
Positive amounts

Generation:
Solar panels (wind, hydro?)



The “grid” of energy consumption

The shapes we are looking at for a day can be put together in a grid for the whole year



1.1	1.1	1.1	1.2	4	6.5	13.3	19.1	24.4	27.1	28.1	28.7	23.8	21	22.5	24.7	24.2	22.9	20.7	22.4	24.6	23.5	22.2	20.4	13.8	5.7	1.8	1.6	1.5	1.4
1.2	1.2	1.2	1.2	4.4	6.5	13.9	18.3	24	27.4	25.1	22.6	19.3	19.2	22.6	18.7	20.3	24.2	16.8	21.2	23.4	21.6	20.2	15.8	11.4	5.4	3.1	1.9	1.8	1.2
1.2	1.1	1.1	1.1	3.1	6.2	13.4	18.2	21.7	22.3	23.3	23.7	19.2	17.4	23.1	21	21.9	21.8	15.7	15.6	20.5	18.1	15.7	13.5	9	2.3	1.7	1.6	1.4	1.3
1.2	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.2	0.8	0	0	0	0	0	0	0	0	0	0.2	0.5	0.5	1.1	1.2	1.3	1.3	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.2	0.9	0.1	0	0	0	0	0	0	0	0	0.2	0.4	0.7	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	3.6	6.4	3.7	17.4	20.2	22.1	23.5	21.1	30.1	25.4	22.9	31.2	28	23	21.7	18.2	23.3	23.3	22.8	19.9	15.4	6.5	1.8	1.6	1.6	1.6
1.2	1.2	1.1	1.1	2.9	6.6	15	28.3	24.6	36.4	20.2	28.8	28.1	28.4	21.9	27.3	26.6	28.9	24.6	22	24.6	28.6	17.4	11.9	1.4	2	4.5	1.8	1.8	1.8
1.2	1.3	1.2	1.2	6.1	7.6	14.5	20.6	24.3	28.1	25.5	27.5	22	26.1	28	27.1	25.7	23.7	17.6	14.6	19.3	24.1	21.9	22.2	14.1	6	1.7	1.6	1.6	1.6
1.2	1.3	1.3	1.3	4.6	6.3	14	17.2	22	22.5	25.2	24.8	22.1	19.8	26.2	25.8	25.9	21.8	17.2	18.1	12	15.7	19.8	19.5	11.7	1.3	1.8	1.1	1.1	1.1
1.2	1.2	1.1	1.1	4.1	6.5	14.1	20.6	19.9	20	28.6	24.3	21.6	20.6	20.3	20.3	19.4	20.7	19.3	12.9	22.5	22.5	12.6	11.1	9.2	2.1	1.3	1.7	1.2	1.2
1.1	1.1	1.1	1.1	1.1	1.1	1.4	1.4	1.3	0.9	0.2	0	0	0.1	0	0.1	0	0	0.1	0.6	1	1.2	1.3	1.4	1.3	1.3	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	0.9	0.4	0	0	0	0	0	0	0	0	0.1	0.7	1.2	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	4.2	5.7	12.1	20.4	21	27.1	30.6	31.5	20.7	26.3	28.9	25.5	24.6	23.6	20.6	24.5	26	25.8	24.5	20.1	16.1	6.8	1.9	1.7	1.3	1.3
1.3	1.3	1.3	1.3	5	7.3	12.8	17.5	19.8	23.1	30.9	30.3	27.1	14	22	28.5	23.4	25.5	20.7	12.3	15	25.4	18.4	15.9	20.1	7.4	2	1.7	1.7	1.3
1.2	1.1	1.1	1.1	4.3	6.4	15.7	19.6	27.7	28.1	30.5	28.4	23.4	17.8	26.2	31.3	27.2	26.1	28.9	15.4	23.5	20	19.8	21.6	12.7	7.8	1.9	1.8	1.3	1.3
1.1	1.1	1.1	1.2	4.1	6.5	15.1	21	26.4	28.7	28.5	30.8	26.2	25.4	27.3	25.7	23.8	26.2	21.3	14.5	24.2	27.7	25.6	23	14.9	4.3	1.8	1.6	1.1	1.1
1.1	1.1	1.1	1.1	3.2	6.6	15.2	20.4	19.7	26.5	25.6	25	24	18.4	25.1	26.2	27.4	23.4	24.1	22.3	23.6	21.8	19.3	20.3	3.5	2.6	1.6	2.2	1.2	1.2
1.1	1.2	1.1	1.1	1.1	1.1	1.4	1.4	1.3	1.2	1.1	0.9	0.8	0.5	0.3	0.3	0.5	0.6	0.7	0.8	1	1.1	1.2	1.4	1.4	1.3	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.4	1.4	1.3	1.1	0.9	0.6	0.5	0.3	0	0	0.2	0.4	0.5	0.8	1	1.3	1.4	1.4	1.3	1.1	1.1	1.1	1.1	1.1
1.2	1.2	1.2	1.2	6.2	6.6	14.4	20.2	23.6	31.7	34.3	30.3	30.4	27.1	26.2	27.9	28.7	28.6	27.1	24.5	27	28	23.8	16.3	19.7	6.3	2	1.7	1.3	1.7
1.1	1.1	1.1	1.2	4.9	6.9	14.5	22.3	30.9	31.7	30.9	31	29	32.7	33.1	30.7	27.7	27	14.6	19.2	27.4	25.3	19.7	22.5	18	5.6	1.3	1.7	1.1	1.1
1.1	1.2	1.1	1.1	5.8	5.7	14.4	32.2	30.3	27.6	32.4	32.2	29.8	30.7	31.1	28.3	33.6	30.8	26.8	26	28.6	29.8	29.3	30.8	20.4	12.2	2.8	3.1	2.8	2.4
1.1	1.1	1.1	1.1	4.1	5.7	14.9	19.1	25.8	30.9	29.8	24.5	19.8	24.1	23.8	28.2	30	27.8	27.9	29.1	27.3	27.1	23	17	11.7	4.6	2	1.6	1.5	1.4
1.1	1.2	1.1	1.1	5	5.5	15	17	23.6	28.9	27.9	24.2	16.1	21.8	26.1	25.7	16	22.2	12.1	3.2	2.1	2.6	1.3	1.3	1.3	1.3	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.2	1.2	0.8	0.5	0.6	0.8	0.7	0.8	0.9	1.2	1.1	1	1.2	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.2	1.1	0.9	0.7	0.6	0.5	0.8	0.5	0.7	0.8	1.1	1.1	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.2	1.1	1	0.7	0.8	0.7	0.4	0.7	0.8	0.7	0.8	1	1.1	1.2	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.1	1.2	0.6	0	0.6	0.2	0.1	0.3	0.1	0.1	0.2	0.8	1	1.3	1.3	1.3	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	5.3	6.3	8.4	13.8	16.5	16.2	25.7	24.3	26.2	19.8	26.8	23.6	19.9	20.6	3.4	3.5	8.4	8.9	11.5	8.9	4	1.5	1.7	1.1	1.2	1.1
1.2	1.2	1.2	1.4	6.6	6.1	12.3	15.4	22	25.5	23.6	26.1	16.1	25.1	29.1	30.4	22.9	23.6	18.4	16.3	13.9	11.4	8.1	5	3.8	2.4	1.6	1.5	1.6	1.1
1.2	1.1	1.1	1.1	4.1	5.6	13.3	20	25.4	25.8	27.7	25.7	19.7	20.2	20.6	22.7	19.7	11.8	3.2	2.8	1.5	1.1	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.1

Week days

Weekend

Christmas

The “grid” of energy use

Electrical usage profiles may come from a predefined library, or actual metered usage

1.1	1.1	1.1	1.2	4	6.5	13.3	13.1	24.4	27.1	28.1	28.7	23.8	21	22.5	24.7	24.2	22.3	20.7	22.4	24.6	23.5
1.2	1.2	1.2	1.2	4.4	6.5	13.3	13.3	24	27.4	25.1	22.6	13.3	13.2	22.6	18.7	20.3	24.2	16.8	21.2	23.4	21.6
1.2	1.1	1.1	1.1	3.1	6.2	13.4	18.2	21.7	22.3	23.3	23.7	19.2	17.4	23.1	21	21.9	21.8	15.7	15.6	20.5	18.1
1.2	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.2	0.8	0	0	0	0	0	0	0	0	0	0.2	0.5	0.5
1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.2	0.3	0.1	0	0	0	0	0	0	0	0	0.2	0.4
1.1	1.1	1.1	1.1	3.6	6.4	3.7	17.4	20.2	22.1	29.5	27.1	30.1	25.4	22.3	31.2	28	29	27.7	18.2	23.3	23.9
1.2	1.2	1.1	1.1	3.2	6.6	15	18.3	24.5	33.1	30.7	29.8	28.1	28.1	21.2	27.6	27.9	25.6	22.2	24.4	27	23.6
1.2	1.3	1.2	1.2	6.1	7.6	14.5	20.6	24.3	28.1	25.5	27.5	22	26.1	28	27.1	25.7	23.7	17.6	14.6	19.3	24.1
1.2	1.3	1.3	1.3	4.6	6.3	14	17.2	22	22.5	25.2	24.8	22.1	19.8	26.2	25.8	25.9	21.8	17.2	18.1	12	15.7
1.2	1.2	1.1	1.1	4.1	6.5	14.1	20.6	19.9	20	28.6	24.3	21.6	20.6	20.3	13.4	20.7	19.3	12.3	22.5	22.5	
1.1	1.1	1.1	1.1	1.1	1.1	1.4	1.4	1.3	0.9	0.2	0	0	0.1	0	0	0	0	0.1	0.6	1	1.2
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	0.9	0.4	0	0	0	0	0	0	0	0	0	0.1	0.7
1.1	1.1	1.1	1.1	4.2	5.7	12.1	20.4	21	27.1	30.6	31.5	20.7	26.3	28.3	25.5	24.6	23.6	20.6	24.5	26	25.8
1.3	1.3	1.3	1.3	5	7.3	12.8	17.5	19.8	23.1	30.9	30.3	27.1	14	22	28.5	23.4	25.5	20.7	12.3	15	25.4
1.2	1.1	1.1	1.1	4.3	6.4	15.7	19.6	27.7	28.1	30.5	28.4	23.4	17.8	28.2	31.3	27.2	26.1	28.3	15.4	23.5	20
1.1	1.1	1.1	1.2	4.1	6.5	15.1	21	26.4	28.7	28.5	30.8	26.2	25.4	27.3	25.7	23.8	26.2	21.8	14.5	24.2	27.7
1.1	1.1	1.1	1.1	3.2	6.6	15.2	20.4	19.7	26.5	25.6	25	24	18.4	25.1	26.2	27.4	29.4	24.1	22.3	23.6	21.8
1.1	1.2	1.1	1.1	1.1	1.1	1.4	1.4	1.3	1.2	1.1	0.9	0.8	0.5	0.3	0.3	0.5	0.6	0.7	0.8	1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.4	1.4	1.3	1.1	0.9	0.6	0.5	0.3	0	0	0	0.2	0.4	0.5	0.8	1
1.2	1.2	1.2	1.2	6.2	6.6	14.4	20.2	23.6	31.1	34.3	30.3	30.4	21.1	26.2	27.3	29.7	28.6	21.1	24.5	27	28
1.1	1.1	1.1	1.2	4.9	6.9	14.5	22.3	30.9	31.7	30.9	31	29	32.7	33.1	30.7	27.7	27	14.6	19.2	27.4	25.3
1.1	1.2	1.1	1.1	5.8	5.7	14.4	32.2	30.3	27.6	32.4	32.2	29.8	30.7	31.1	28.3	33.6	30.8	26.8	26	28.6	29.8
1.1	1.1	1.1	1.1	4.1	5.7	14.3	19.1	25.8	30.9	29.8	24.5	18.8	24.1	29.8	28.2	30	27.8	27.9	23.1	27.3	27.1
1.1	1.2	1.1	1.1	5	5.5	15	17	23.6	28.9	27.9	24.2	16.1	21.8	26.1	25.7	16	22.2	12.1	3.2	2.1	2.6
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.2	1.2	0.8	0.5	0.6	0.8	0.7	0.8	0.9	1.2	1.1	1	1.2
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.3	1.2	1.1	0.9	0.7	0.6	0.5	0.8	0.5	0.7	0.8	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.2	1.1	1	0.7	0.8	0.7	0.4	0.7	0.8	0.7	0.8	1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.3	1.3	1.1	1.2	0.6	0	0.6	0.2	0.1	0.3	0.1	0.1	0.2	0.8	1
1.1	1.1	1.1	1.1	5.3	6.3	8.4	13.8	16.5	16.2	25.7	24.9	26.2	19.8	26.8	23.6	19.3	20.6	3.4	9.5	8.4	8.9
1.2	1.2	1.2	1.4	6.6	6.1	12.3	15.4	22	25.5	23.6	26.1	16.1	25.1	29.1	30.4	22.9	23.6	18.4	16.3	13.9	11.4
1.2	1.1	1.1	1.1	4.1	5.6	13.3	20	25.4	25.8	27.7	25.7	19.7	20.2	20.6	22.7	19.7	11.8	3.2	2.8	1.5	1.1

Definition of electrical consumption by imported load profiles

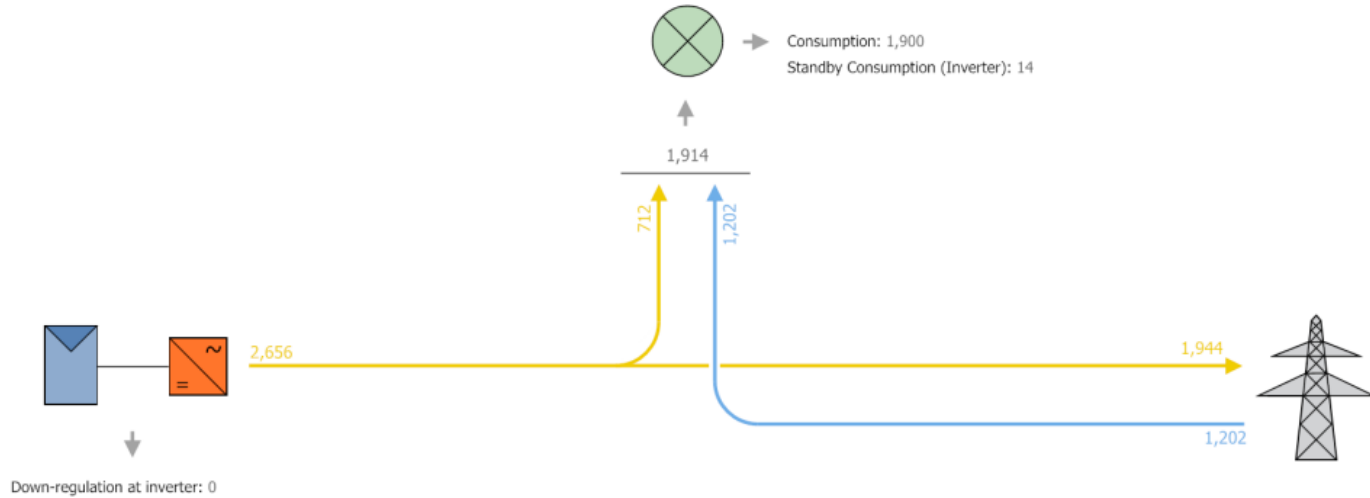
Import new load profile | Delete Load Profile

- BDEW load profile agriculture (L2)
- Brasil Centro Oeste
- Brasil Nordeste
- Brasil Norte
- Brasil Sudeste
- Brasil Sul
- Household, seasonal course comparable with standard profile
- Household, load profile with high night proportion
- Household, load profile with high summer proportion
- Household, Load profile with high percentage of morning hours
- Household, Load profile with low percentage of nighttime hours
- Household, load profile with low summer proportion
- Household, Load profile with low percentage of morning hours
- Household, diurnal course comparable with standard profile
- Load profile with constant load
- School HH data for PVsol
- School HH data for PVsol
- Heat pump
- Heat Pump System with Space Heating (air/water)
- Heat Pump System with Space Heating (brine/water, geothermal collector)
- Heat Pump System with Space Heating (brine/water, geothermal probe)
- Heat Pump System with Space Heating (water/water)
- Heat Pump System with Space Heating and Domestic Hot Water (air/water)
- Heat Pump System with Space Heating and Domestic Hot Water (air/water) with Heating Element
- Heat Pump System with Space Heating and Domestic Hot Water (brine/water, geothermal collector)
- Heat Pump System with Space Heating and Domestic Hot Water (brine/water, geothermal probe)
- Heat Pump System with Space Heating and Domestic Hot Water (water/water)
- Ynsowen csv

Results

Energy Flow Graph

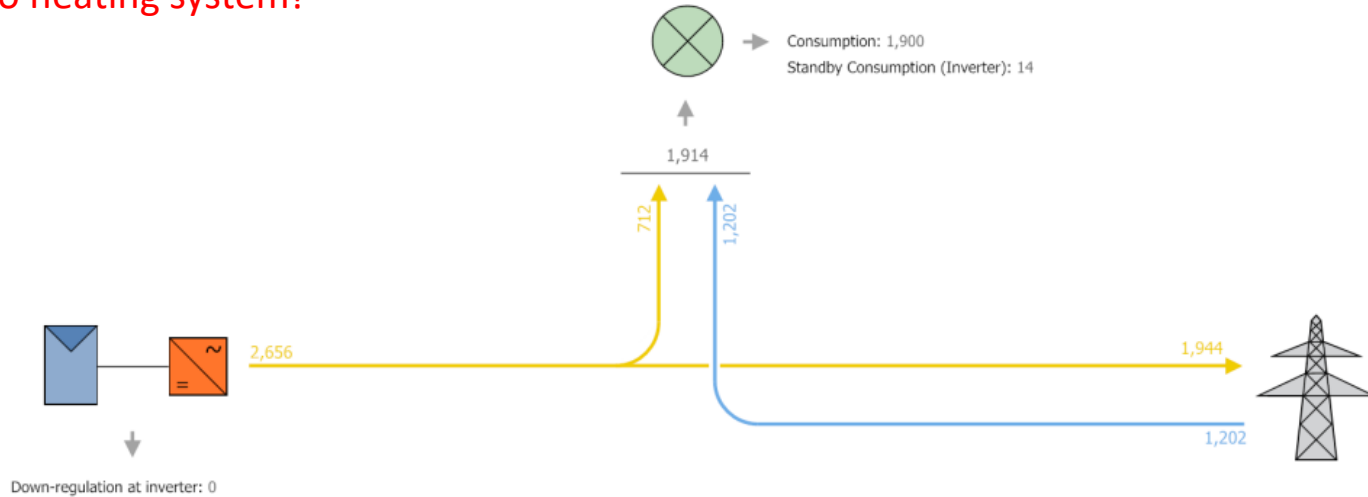
Project: Social housing bungalow



Energy Flow Graph

Project: Social housing bungalow

No heating system!



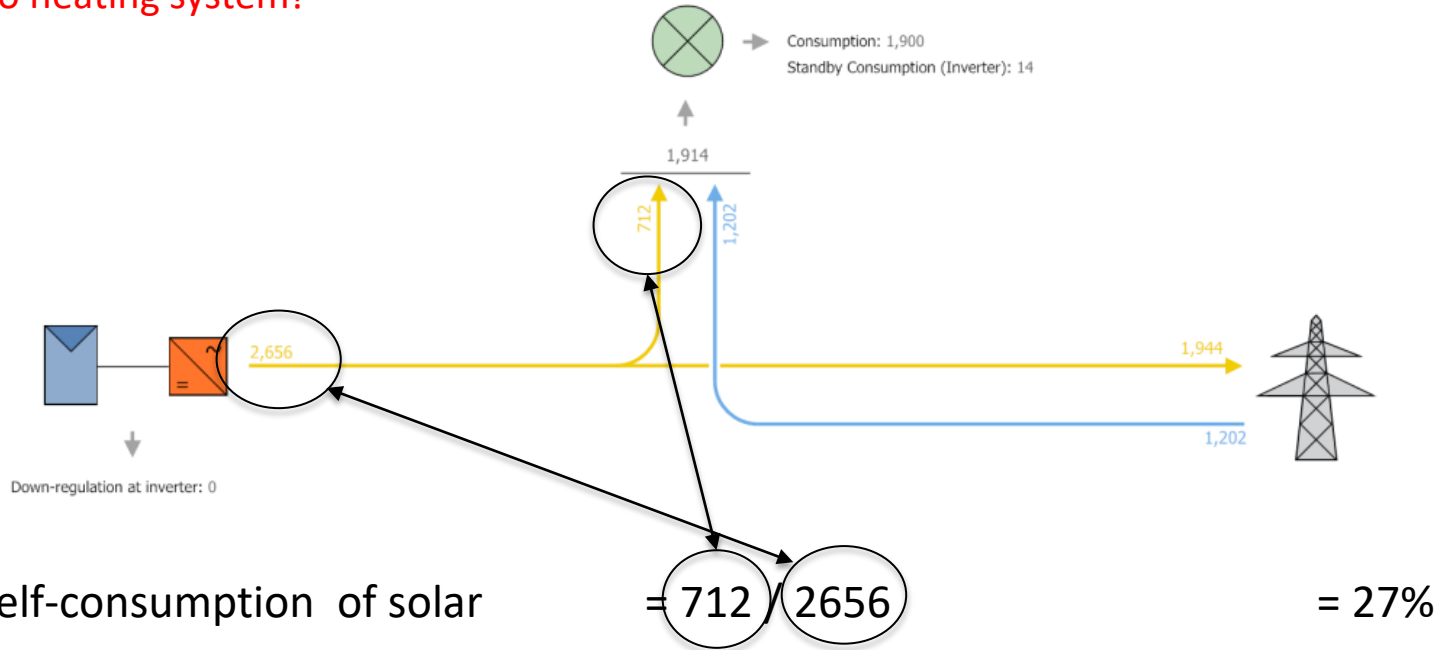
Self-consumption of solar	= 712 / 2656	= 27%
Solar fraction electricity use*	= 712 / 1914	= 37%

*solar fraction = % of overall electricity use delivered by the solar system

Energy Flow Graph

Project: Social housing bungalow

No heating system!

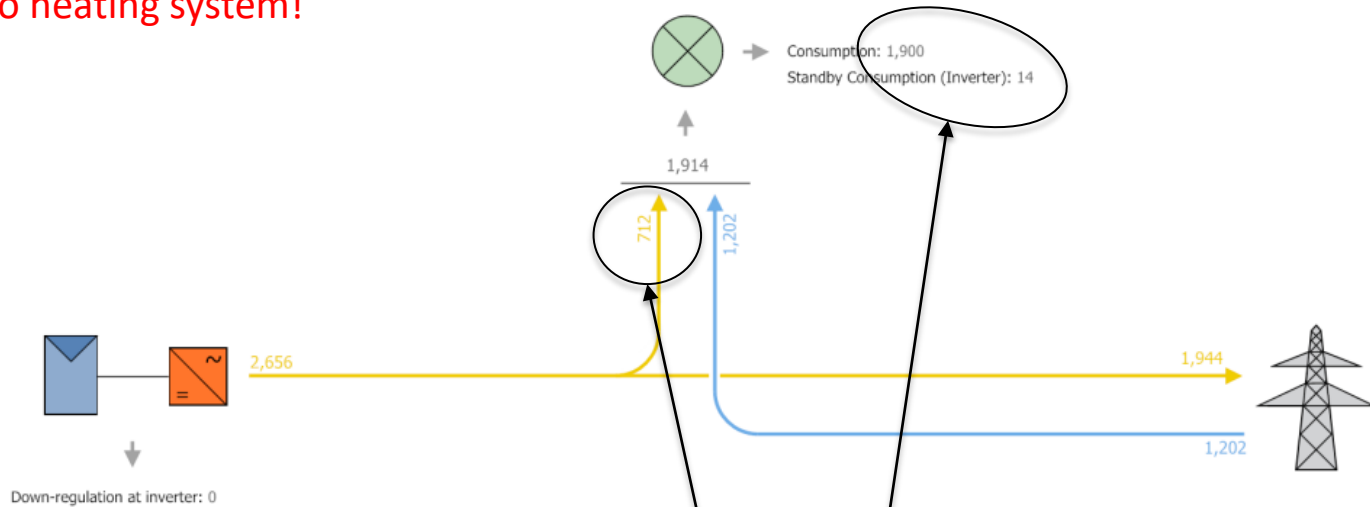


*solar fraction = % of overall electricity use delivered by the solar system

Energy Flow Graph

Project: Social housing bungalow

No heating system!



Solar fraction electricity use*

$$= \frac{712}{1914}$$

= 37%

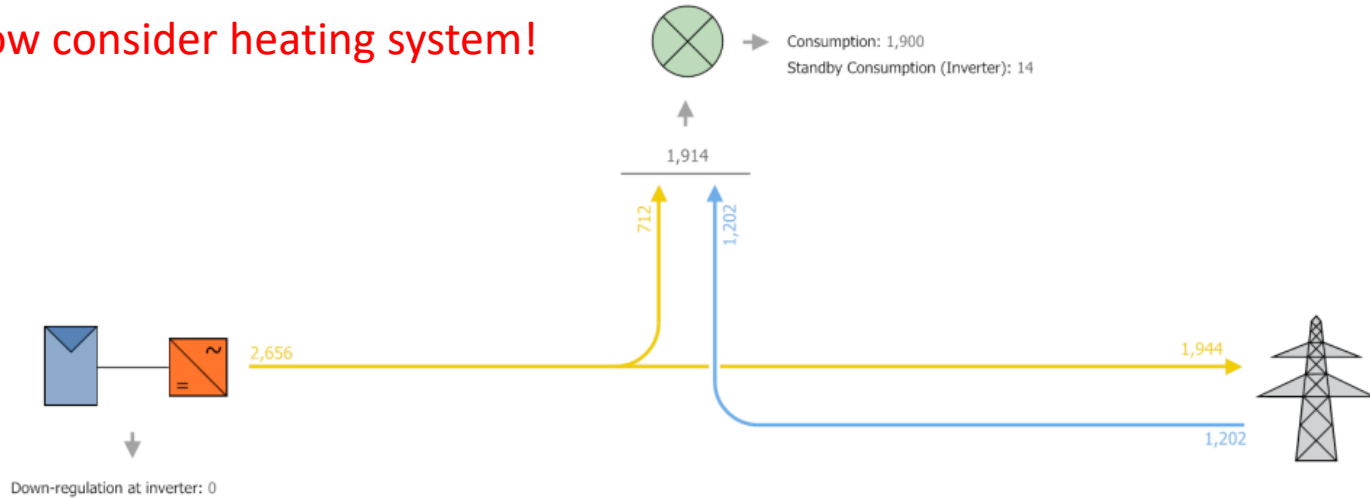
*solar fraction = % of overall electricity use delivered by the solar system

Energy Flow Graph

Project: Social housing bungalow

Results

Now consider heating system!



Self-consumption of solar = $712 / 2656$

= 27%

Solar fraction electricity* = $712 / 1914$

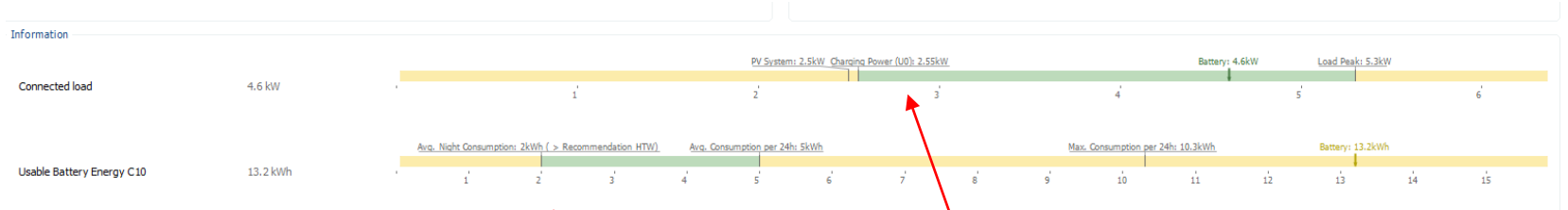
= 37%

Solar fraction total house energy = $712 / [1914 + 12,000]$

= 5%

Electricity + Gas
TDCV

Now add a battery



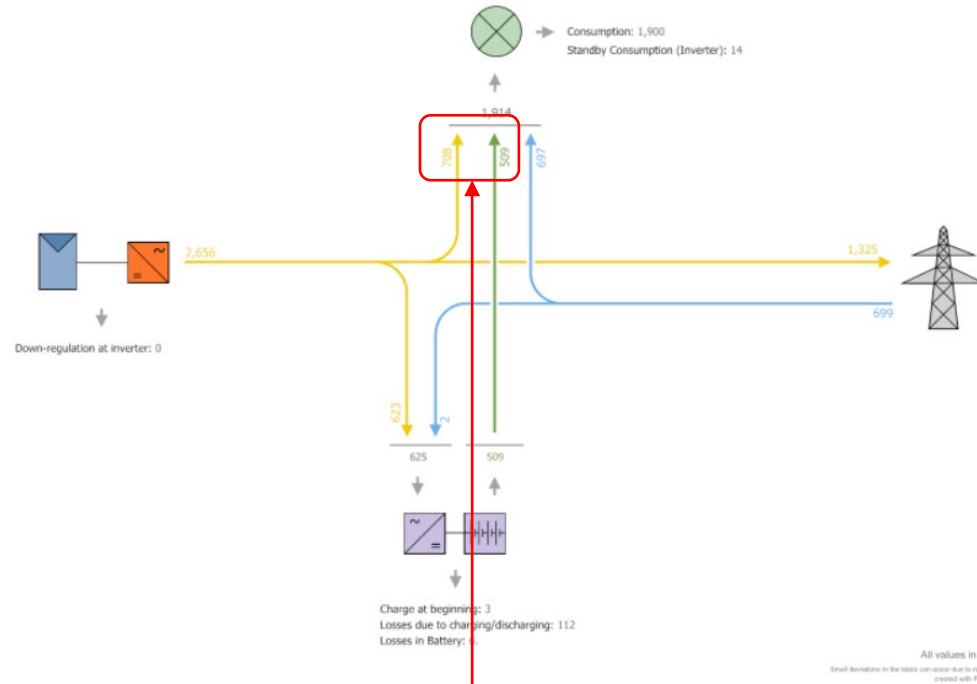
Charging Power

PV System: 2.5kW Charging Power (UD): 2.55kW

Storage Capacity

Avg. Night Consumption: 4kWh Recommendation HTW: 5.9kWh Battery: 6.4kWh

3 4 5 6 7 8



Model results

3kW PV
2.6kW charge
5.9kWh batt
No heat pump

Self-consumption of solar
Solar fraction electricity*

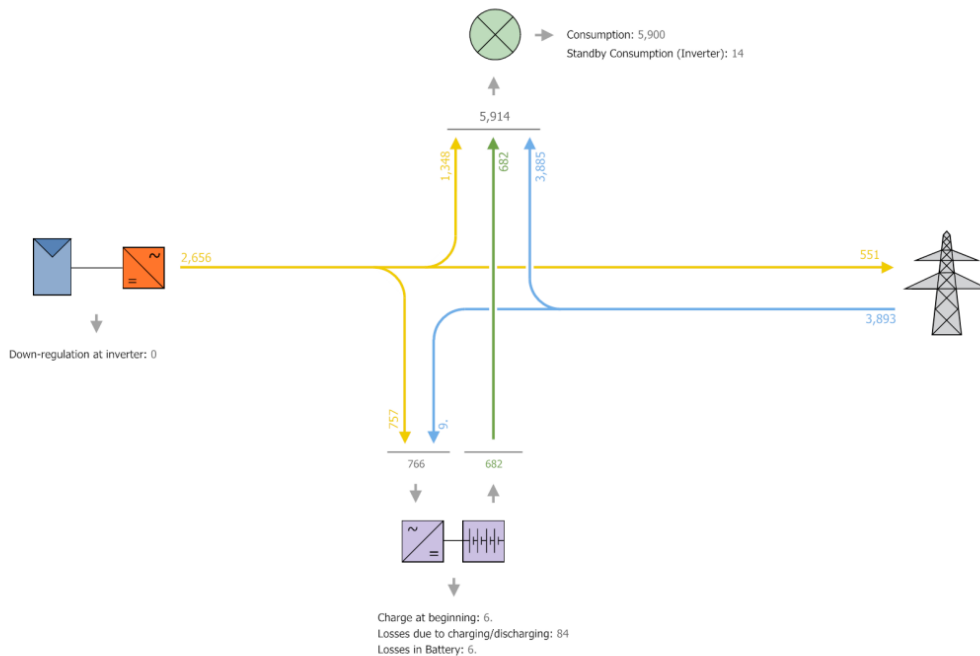
Solar fraction total house energy = $(708+509) / (12,000 + 1914) = 9\%$ previously (5%)

*solar fraction = % of overall electricity use delivered by the solar system

Heat + Electricity

= 45% previously (27%)

= 63% previously (37%)



All values in kWh
Small deviations in the totals can occur due to rounding
created with PV*SOL

Model results

3kW PV
3.5kW charge
9kWh batt
Heat pump

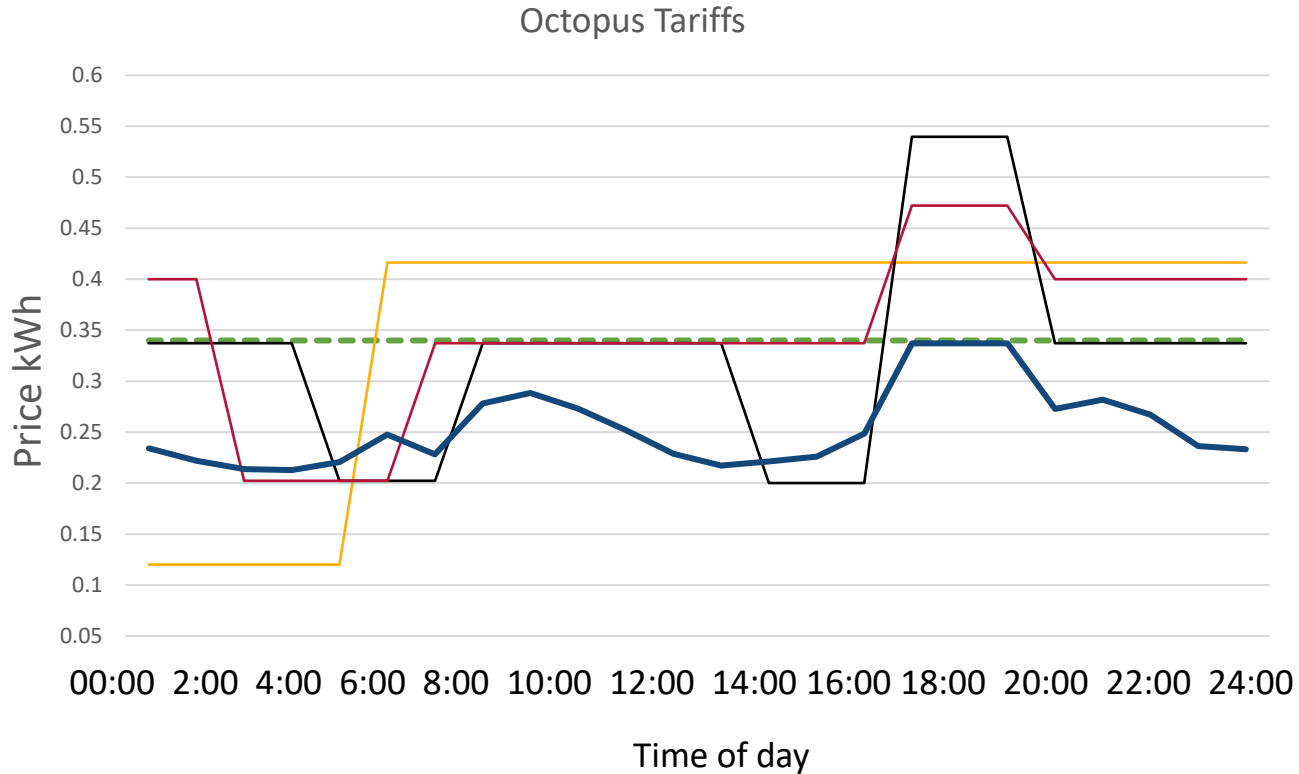
Self-consumption of solar
Solar fraction (now total energy)*

= 76% (previously 27% then 45%)
= **35%** (previously 5% then 9%)

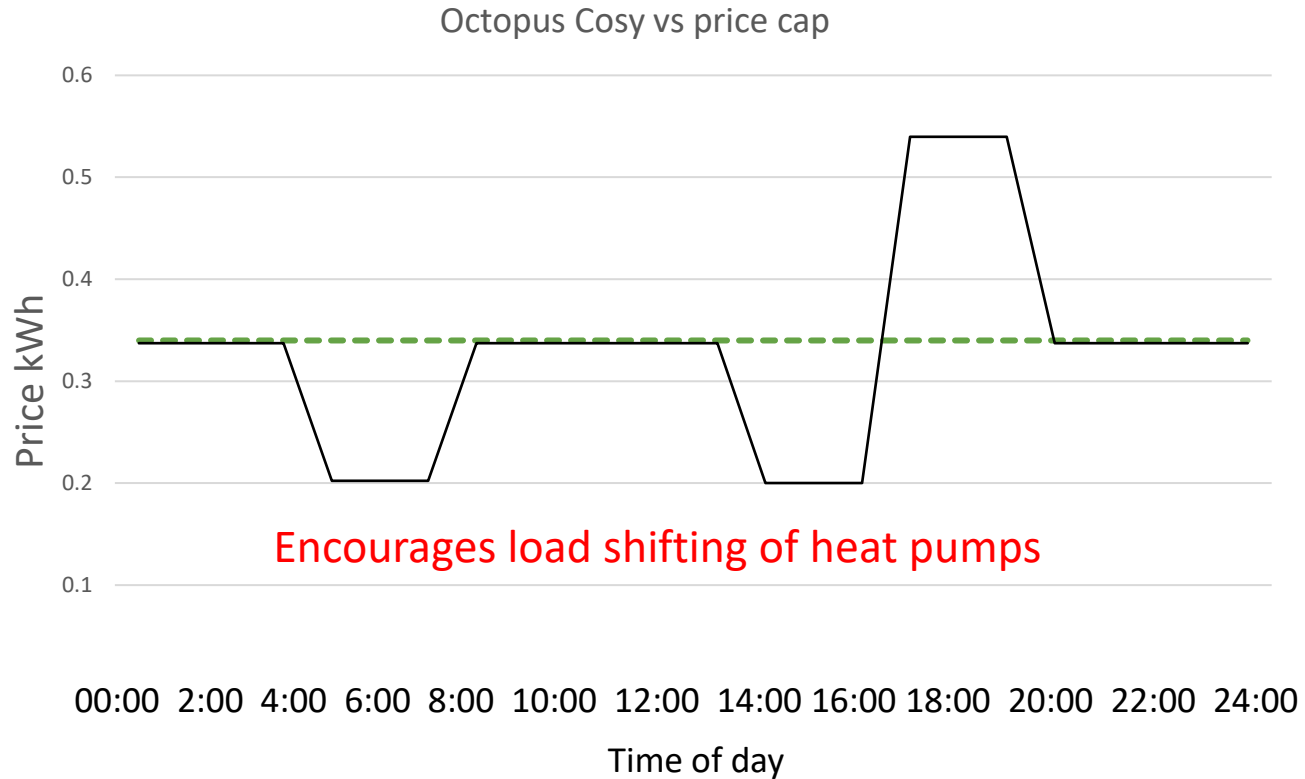
How do we go about modelling renewables?

1. Choose a location > get solar and climate information
2. Select system size > get amount of energy produced
3. Create a “grid” of electricity use and generation
4. Sum all the positive and negative amounts
5. Result > an energy system balance
> an idea of running costs
6. Compare “grid” to different tariffs
7. Consider load shifting

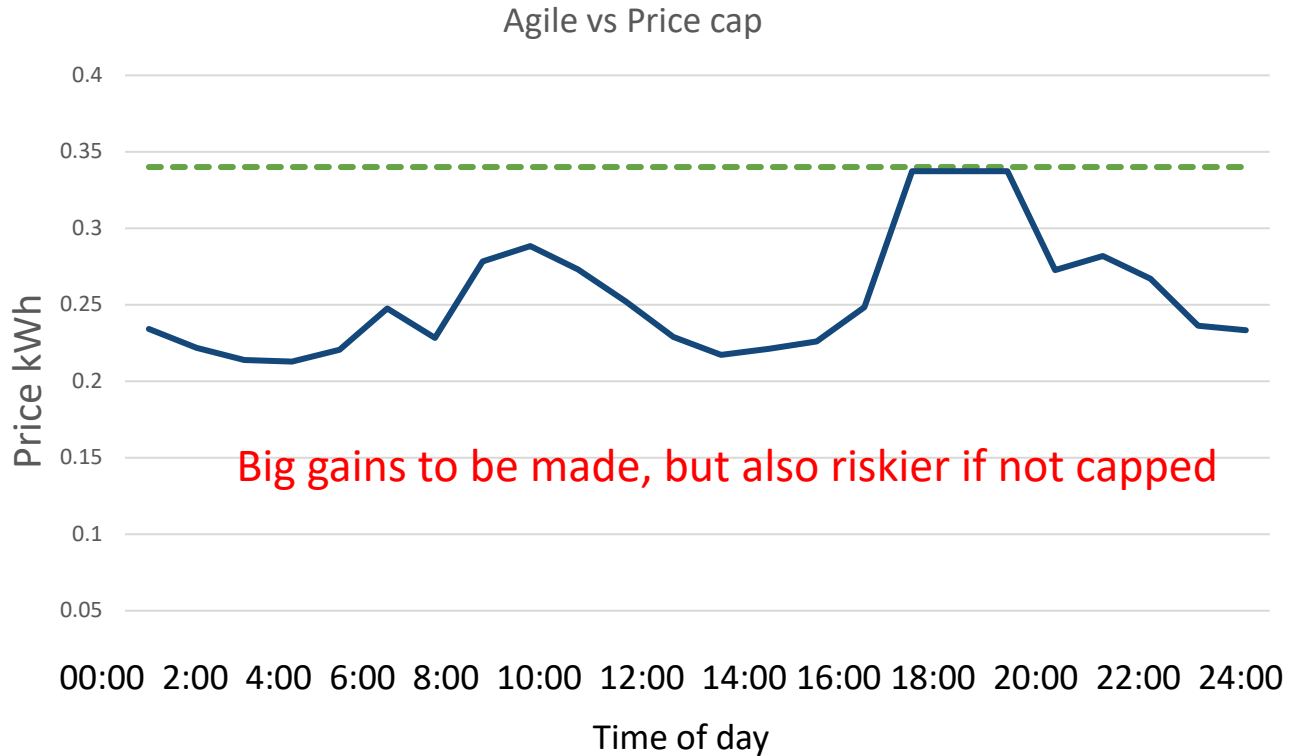
Extracting extra value through time of use tariffs



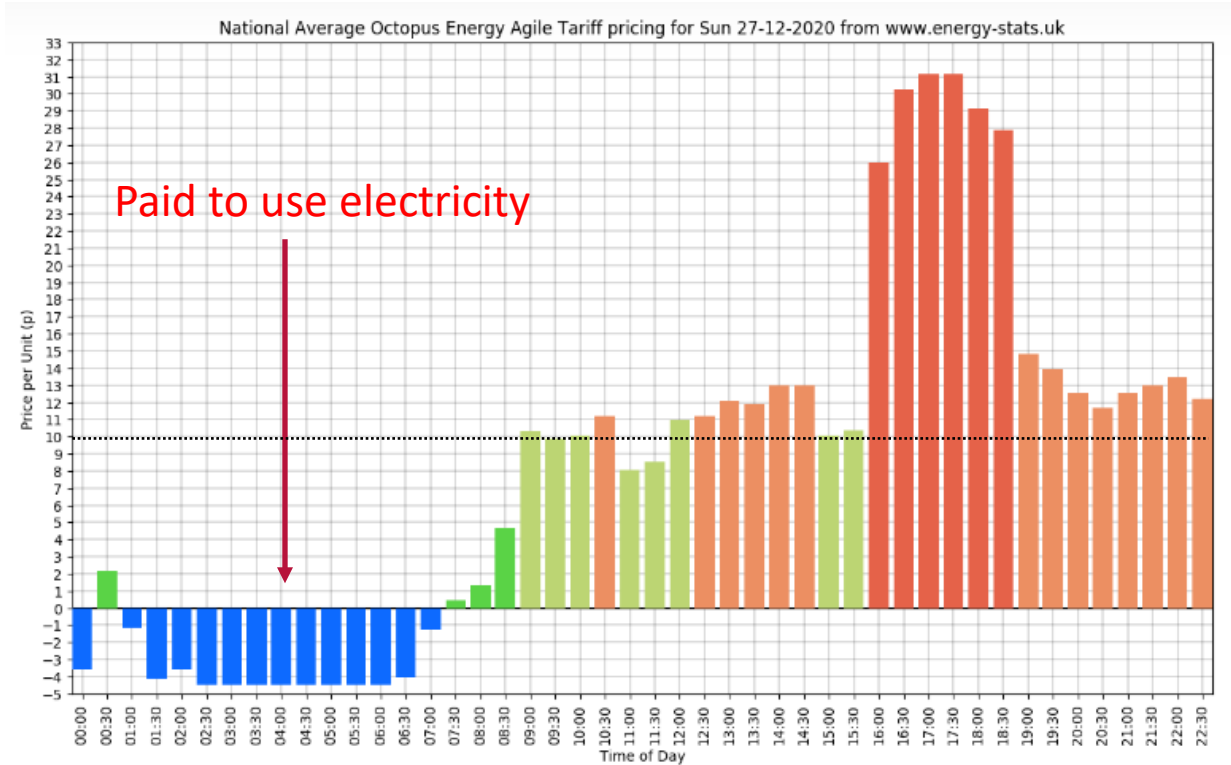
Extracting extra value through time of use tariffs



Extracting extra value through time of use tariffs



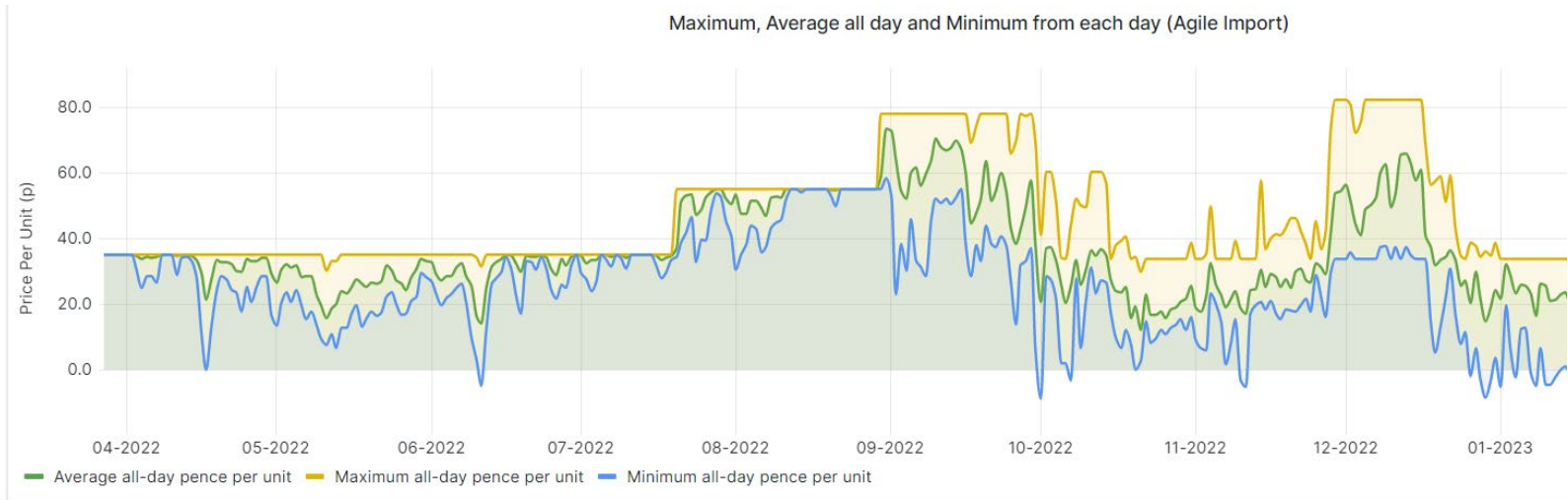
One “good” day of Agile in 2020



Average
about
10p/kWh

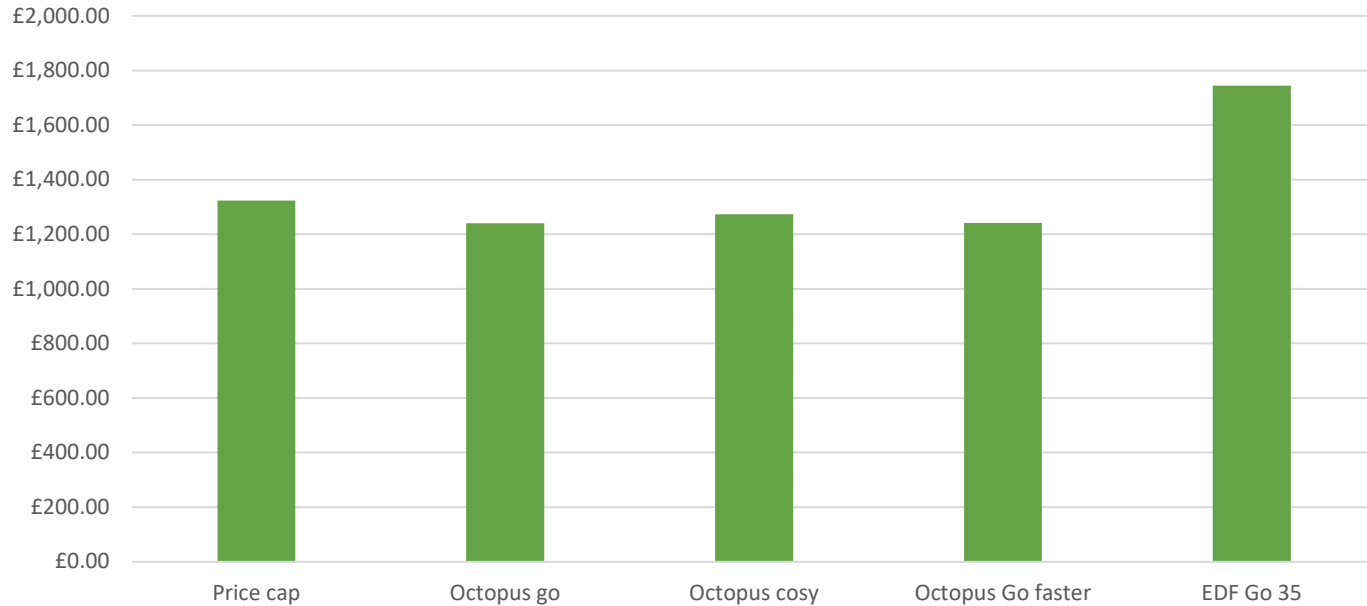
How bad it got in 2022

Peaks at 80p/kWh



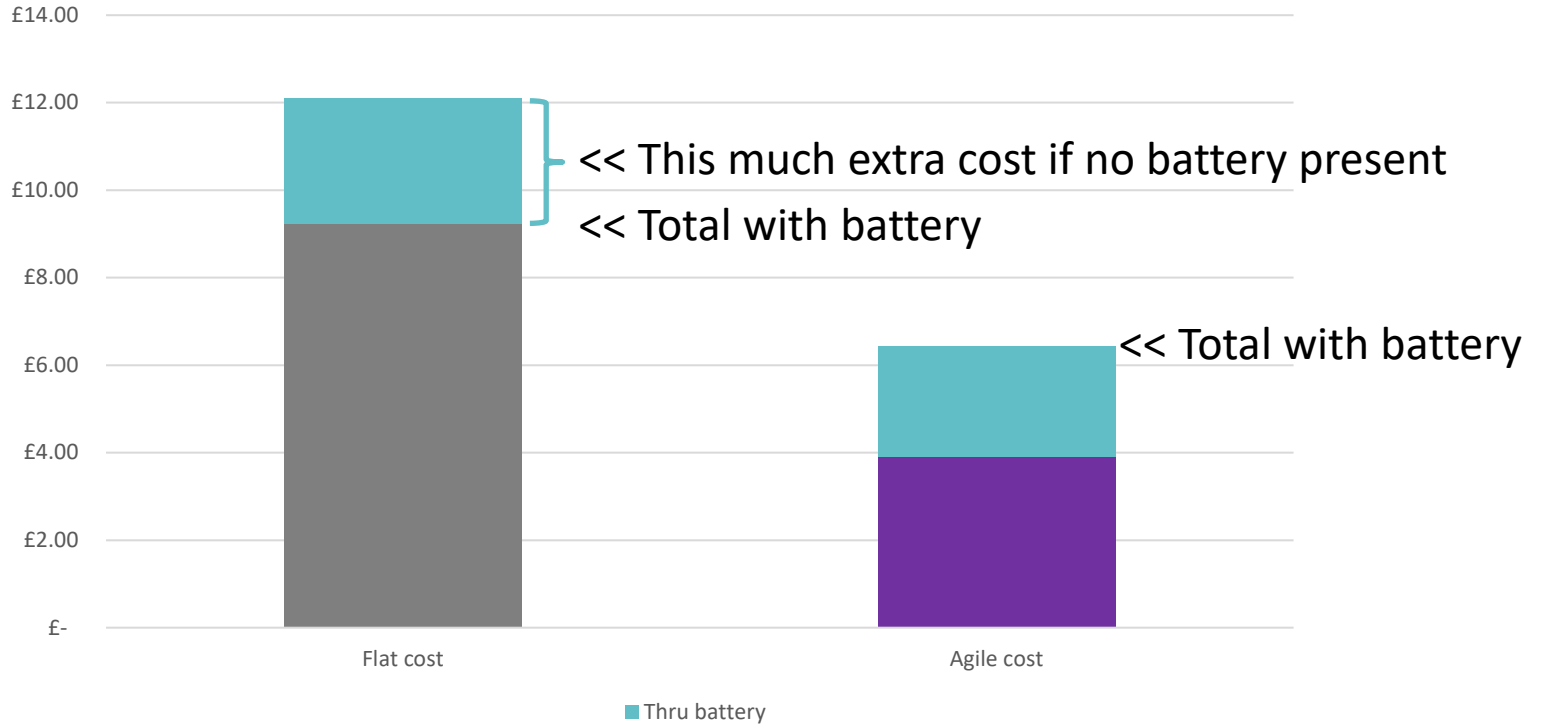
Extracting extra value through time of use tariffs

Comparative pricing - no load shift – to heat a house with a heat pump



One day in April

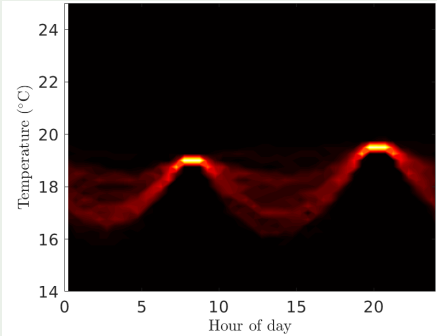
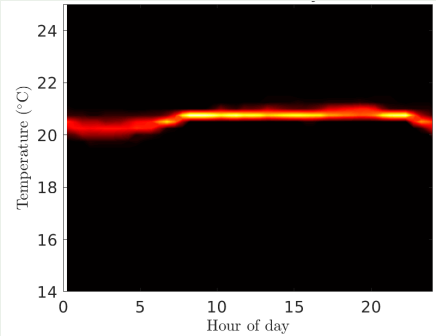
Agile and battery vs flat rate and battery



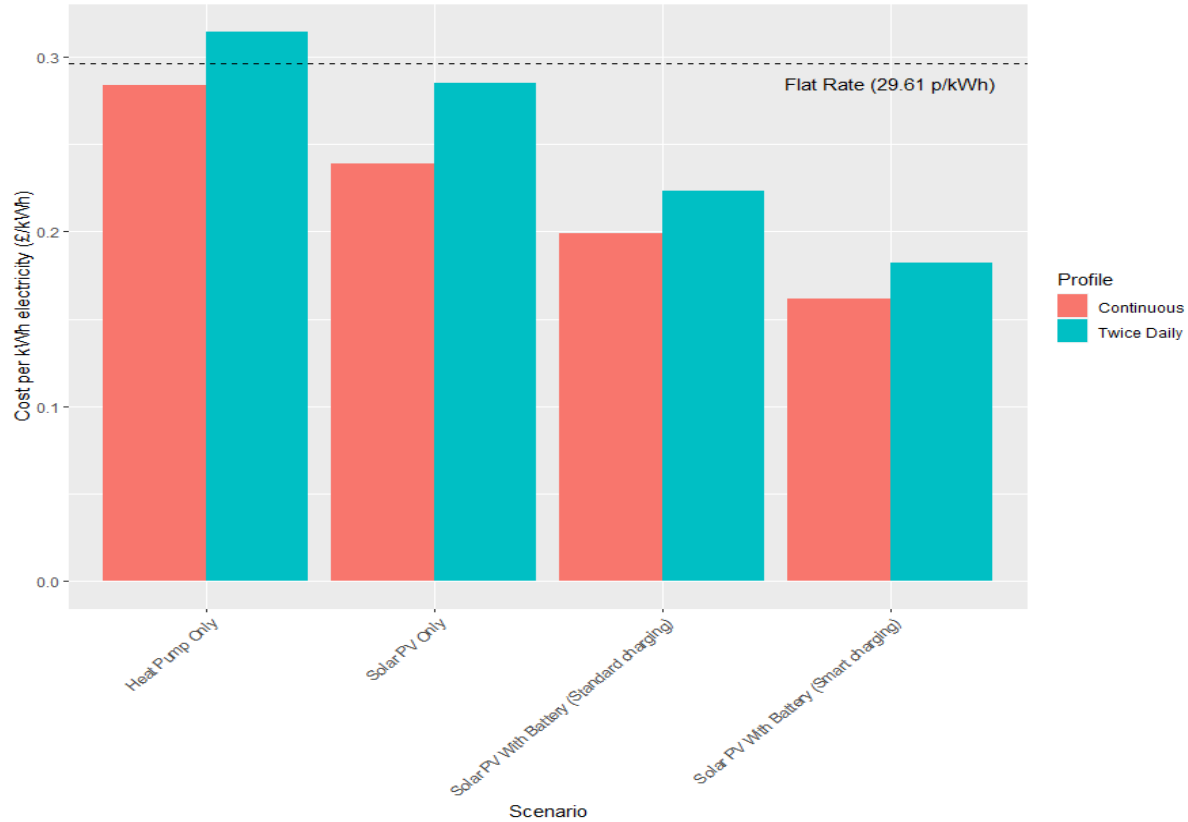
Methodology Slide

- Two EoH properties
- Three months during the winter period (October –December)
- Only considered space heating
- Grouped to half hourly data
- Modelled energy flows with/without solar PV and battery
- Applied different logic to battery charging
 - Standard: battery only charges from PV using excess generation and discharges to home preferentially to importing from grid.
 - Smart: battery charges from grid during low cost times (other times same as standard). Discharges as standard.
- Applied time of use carbon and cost factors to half hourly data

Two different heating patterns same heat pump (different properties)

Profile	Twice Daily	On all day
Electricity consumption	635 kWh	1297 kWh
Heat output	1712 kWh	5311 kWh
SCOP (3 month period)	2.7	4.1
Assumed set point	19.5°C	21°C
Average Int temp	18.1°C	20.5°C
Heating Profile		

Impact on cost & carbon (cosy)



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Green Homes Network

Torin Clarke

13/09/23

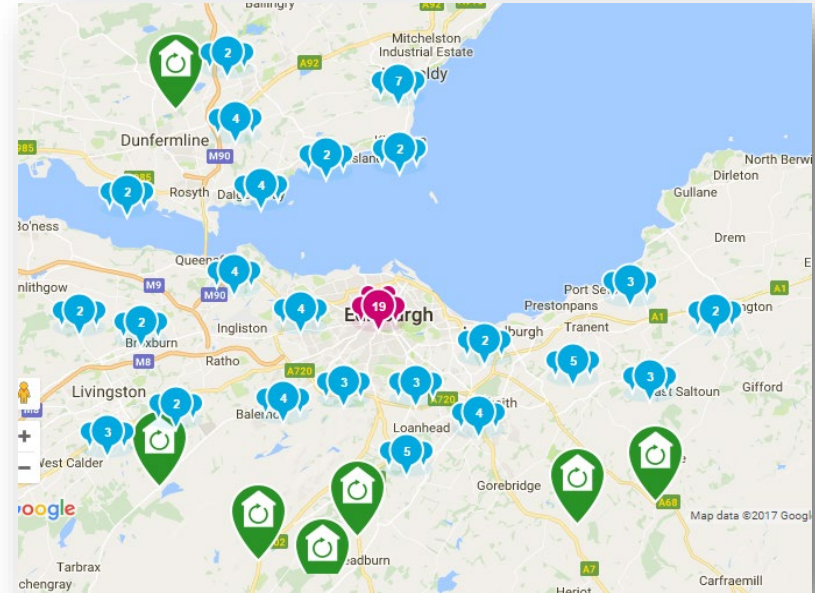


Takeaways

- What is it?
- How do you use it?
- Why should you use it?

What is the Green Homes Network?

- A network of over 350 households across Scotland which have installed renewables and energy efficiency measures
- Hosted on a free-to-use searchable database, case studies vary from old stone cottages to new builds, and everything in-between
- Case studies provide honest feedback about experiences installing, and living with, different sustainability measures



How do you use the database?

Green Homes Network

Welcome to the Green Homes Network which is a database of case studies submitted by members in Scotland who have installed energy efficient and renewable measures in their homes.

Select from the options below to find a green home case study in Scotland. Read about their project and request to contact the member for more information.

[Add my home](#)

Select from the options below to find a green home near you (the network is in Scotland only)

Postcode or area (required)

Distance 25 miles 50 miles 100 miles 300 miles

Optional filters

Selecting more than one filter option will expand the results to include those that meet one, both, or multiple criteria.

Energy saving measure(s) Renewable technologies installed

Property type Age of property



If you would like to arrange a visit, click below and fill in your details.

[Visit this property](#)

Jim Hewlett lives in a detached two-bedroom house that was built more than 110 years ago. He wanted to reduce the environmental impact of his property whilst also saving money on his energy bills. His home is made entirely out of brick and has no cavity spaces which means it can get quite cold during the winter months.

Jim's energy efficiency journey started in 2011 when he received a cold call from a solar panel installer who surveyed his property and installed a 2.7kW solar PV system. Jim was satisfied with his new system but had to replace the inverter after six years at a cost of £2,726. The actual inverter was £1,200. The larger sum included the additional fitting of micro inverters to each panel. Two of the micro inverters failed almost immediately but because they were covered under warranty they were replaced at no extra cost. Jim's solar PV system was expensive by current standards, but the cost was offset by the higher Feed in Tariff payments which were on offer in 2011.

Since then Jim has contacted Home Energy Scotland for advice on which other renewable technologies he could install to further improve the environmental performance and comfort of his home. His next step was to install a ground source heat pump which could use the electricity generated by the solar panels and turn it into efficient and clean heat. The installation process required a 450m trench to be dug on the property, this displaced 226 cubic meters of mud which made the property messy for a period of time. However, once installation was complete Jim could remove his oil tank and oil burner, freeing up more outside space.

Jim also installed external solid wall insulation to improve the property's thermal performance and make it more energy efficient. Heat pumps are a very efficient form of electric heating but can still be expensive if installed in older homes with low insulation levels. Jim accessed the Scottish Government funded Home Energy Efficiency Programme for Scotland (HEEPS) programme which subsidised his external cladding. Jim was impressed by how the cladding removed the chilly areas of his home while at the same time improving its external appearance.

Finally, Jim purchased an electric vehicle and installed a chargepoint. Jim funded these with an interest-free loan from Energy Saving Trust. Jim can charge his car using electricity generated by the solar PV panels which means it is cheaper to run than on regular mains electricity and considerably cheaper than a regular petrol or diesel engine car.

Jim now enjoys free electricity and heating thanks to the renewables he has installed at his home. This has allowed him to invest in further energy efficient improvements such as LED lighting and A-rated appliances and solar charged batteries.

His advice for other homeowners considering improving their homes is to "use your own, don't prejudice and, get the digger driver to put the clay back flat."



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[f](#) [t](#) [in](#) [8](#)

Visit: <https://energysavingtrust.org.uk/tool/green-homes-network/>

Apply your search criteria, review a case study from the list and complete a simple contact form



Opportunities
straight ahead

Getting the word out

- The network is more popular than ever with thousands of users viewing case studies tens of thousands of times each year
- Members regularly speak to the media, support educational events and even get involved in research studies
- Case studies often mention installers used

MEET TOBY >

MEET RUTH >

David and Pauline
David and Pauline installed because 'reducing our home's total energy use just made sense. If you want to reduce your carbon emissions, heat pumps are great.'

Gordon
Gordon says the decision to install a heat pump and solar panels in the home his family were building 'was definitely one worth making.'

MEET DAVID AND PAULINE >

MEET GORDON >



Act now, save later

EDITORIAL

Heat with the air source heat pump that made her rental property

Home Energy Scotland advisers can help you to make your property more energy efficient – and save you money

HERE are lots of reasons why improving the energy efficiency of your properties is a positive decision for you and tenants. For example, making your properties more energy efficient will add value, make your properties attractive to new tenants, lead to a turnover of tenancies, and reduce initial problems such as damp. Improving energy efficiency should increase your owners' returns:

- the recommended improvements
- the approximate cost of making these improvements
- potential fuel bill and carbon savings
- any potential income you could make from installing a renewable system
- the estimated improvement in the Standard Assessment Procedure (SAP) score.

How one landlord improved her property's EPC ratings

pump which, plus radiators and hot water cylinder cost a total of £1,500. The energy savings of £30 per month (which Ruth benefits from because her tenant's rent is inclusive of bills), plus Renewable Heat Incentive payments of £240 she receives (payable quarterly for seven years, but which closes to new applicants on 31 March 2022), more than cover her loan repayments of £176 per month. Ruth's cottage is now fully renovated and has achieved an EPC rating of B. She

Home Energy Scotland

HOME VIDEOS PLAYLISTS >

Ground Source Heat Pumps
1:18
127 views • 8 months ago

Green Homes Network - Discover your home's potential
14:39
158 views • 1 year ago



THE TIMES
SCOTLAND

The Telegraph

“Great to speak to someone who changed from storage heaters to an air source heat pump. I had a very useful conversation about his experience having it installed. I found out about the savings he is getting and how it operates in real life. It puts my mind at rest that I am making the right decision.”

“The visit on Sunday went very well, thank you for arranging this. The member was extremely knowledgeable and helpful. I was reassured by his experience of installation and heating with the ASHP to date.”

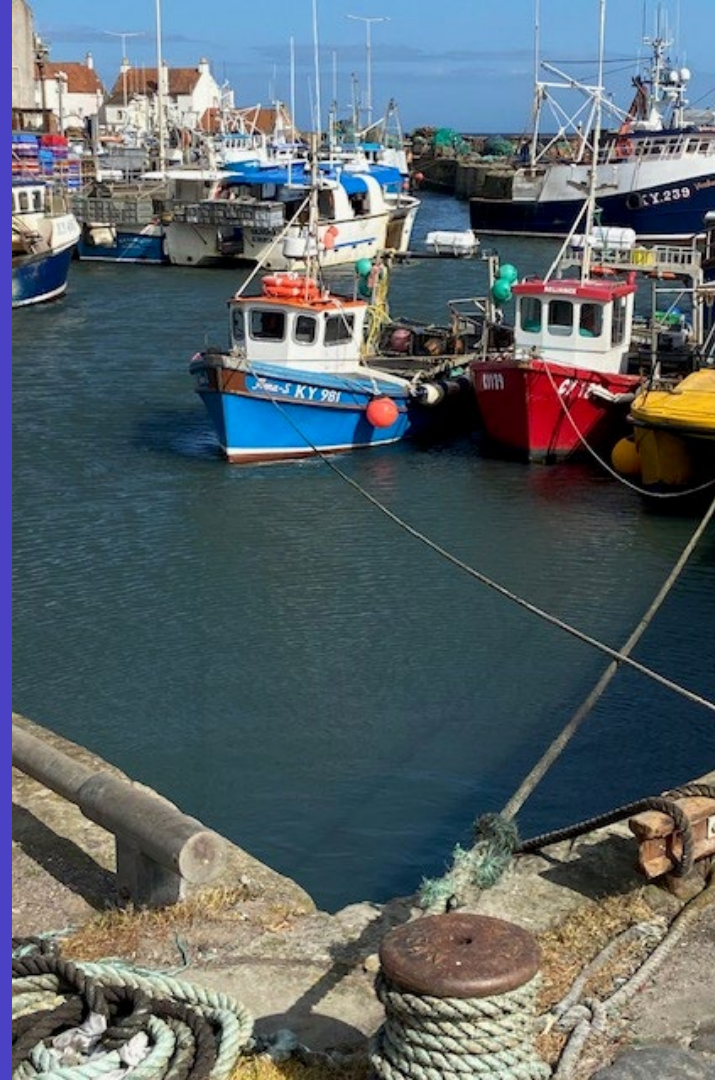
energy
saving
trust



Thank you

Living with integrated heat pump, solar PV, and battery storage systems

David Stutchfield, Pittenweem, Fife





Summary

- **115m² 3 bedroom detached house**
- **Exposed location beside sea in Fife**
- **Both retired, but were working from home before**
- **Upgraded from EPC E to EPC A rating over 15 years**
- **House annual carbon emissions down from 2.7 to 0.6 tCO₂e**
- **House is more comfortable to live in**



Solar Thermal

- **3m² AES flat plate panel inst 2007**
- **Supplemented wood stove back boiler (now removed)**
- **Dual coil DHW cylinder replaced when heat pump installed**
- **Provides 67% annual hot water, (95% summer 35% Dec/Jan)**
- **Super insulated box over cylinder reduces losses 10%**



Heat Pump

- **7kW Vaillant AroTherm Plus, installed by BEIS Electrification of Heat project**
- **New heating system, all radiators 3x size with TRVs**
- **Low temperature continuous heating is superb - creates much better living environment than radiators that are too hot to touch and are only on for short periods of time.**
- **App easy to use for day to day changes**

Heat Pump Controls



- Heating set 19C day, 17C after 10pm, 18C at 2am (Cheap tariff)
- Seasonally commissioned by me - most aggressive OA compensation curve set (until house wasn't warm - then backed off) - now max flow temp 38C
- Anti-legionella cycle turned off & DHW set to 50C
- Issue with leaking air vent after a service - replaced and moved

Heat Pump Learning Points

- **Original quote showed annual heat pump electricity consumption expected to be 6,780kWh for 21,600kWh heat consumption - quite alarming.**
- **Previous system gas boiler consumed annual 9,900kWh gas -do ask about customers previous bills. Last year heat pump actually used 1,900 kWh delivering 6,900kWh heat.**
- **Very disruptive during installation - team in all rooms at once for 3 days (we sat out in garden each day)**
- **Worried about fan noise, but system operates silently**
- **Installer set very conservative controls - changes I have made give ~20% + savings**
- **Since installation I have installed triple glazing so probably 5kW heat pump would suffice.**

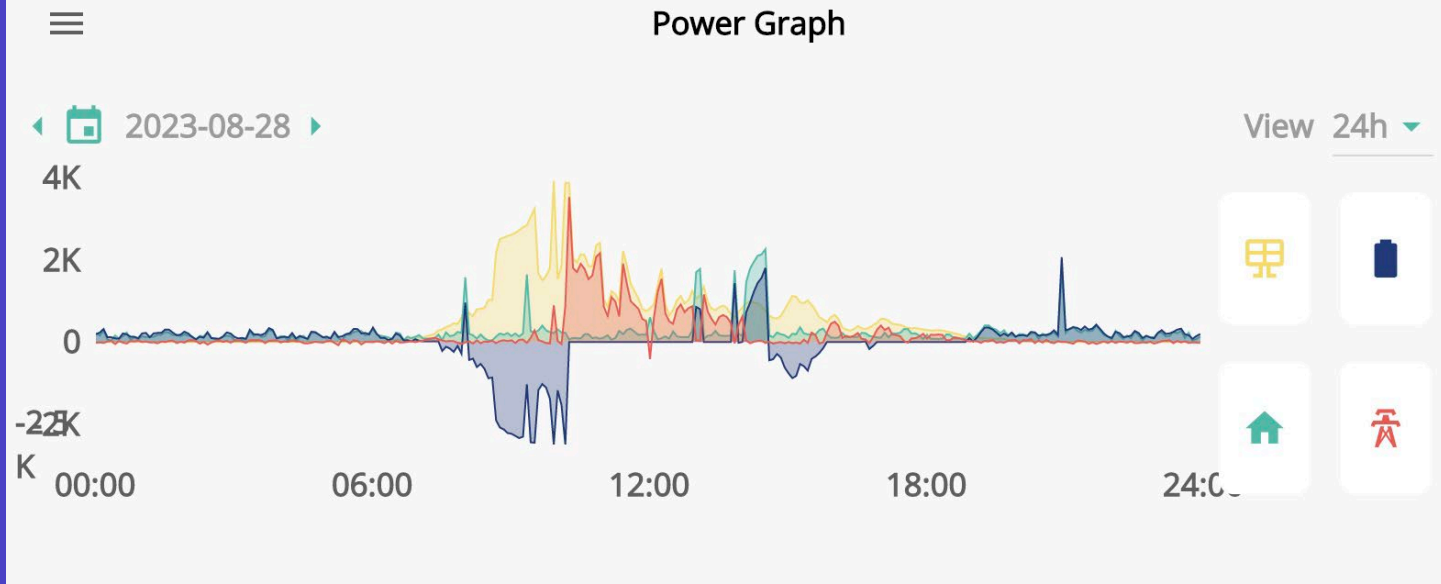


Solar PV/ Battery



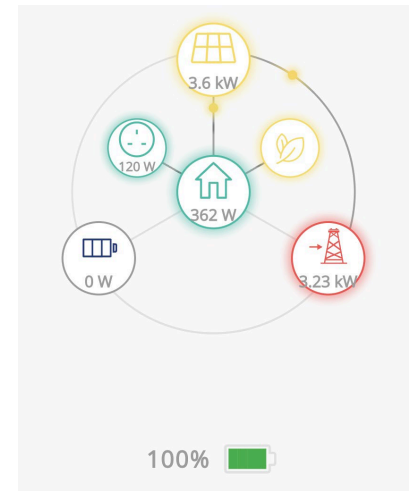
- **4kWp Solar PV (10 panels)**
- **3.6kW hybrid inverter & 8kWh battery installed in combe space**
- **Sized to maximise renewable energy use**
- **Easy to change charging / discharge strategy in App and website**

Solar PV/ Battery Operation



- **Initially daily look at graphs / now just content all works.**
- **Operation changes winter / summer and with tariff**
- **Now on Octopus Flux - in winter charge both EV and battery fully between 2-5am @17.8p/kWh**
- **In summer batteries store PV generation, so bills show only export to grid**

Solar PV/ Battery Learning Points



- **When system installed export @ 4.5p/kWh, so ran system to maximise self use of PV, but now getting 18.7p/kWh, so cheaper to charge EV at night than charge off PV during day even in summer.**
- **Assumed we would get island mode capability - would now insist on external earth during install (retrofit very expensive).**
- **Would now install 13.5kWh battery and inverter capable of delivering up to 6.5kW & island mode.**

General Learning Points

- **Started with a well insulated draughtproof house - invested £10k over the years on insulation and £15k on new windows.**
- **Probably wouldn't install solar thermal - PV generation through a heat pump can efficiently generate hot water.**
- **Current inverter can only produce 2.5kW from battery - made changes to how we use the kitchen ie a 3kW kettle changed to 1.5kW kettle (takes longer to boil) / don't put the kettle and toaster on simultaneously**
- **Heat pump pulls 3kW on startup so cannot run 100% from battery.**

11:05

< Graphed Circuit

 **B12DAC** ^

 **Main**

 **Solar PV**

 **Heat Pump**

 **Heat Pump controls**

 **EV charger**

 **Cooker**

 **Kitchen ring**

 **Ground floor ring**

 **Upstairs ring**

 9

 10

 11

General Learning Points

- **Participated in demand response trial - being paid to not use electricity at peak times in winter (heating setpoint lowered during period to ensure heat pump not operating / ensure battery full before hand)**
- **Battery 94% efficient in charge / discharge cycle**
- **Still have gas installed for cooking hob, but will probably change to induction.**





**David
Stutchfield**

Pittenweem

Thank you

<https://greenhomenetwork.energysavingtrust.org.uk/CaseStudy.aspx?cid=1677>

You can ask questions by typing them into the questions box of the control panel

Panellists:

Pilar Rodriguez	Programme Manager, Green Heat Installer Engagement Programme, Energy Saving Trust
Ben Whittle	Senior Low Carbon Consultant, Energy Saving Trust
Torin Clarke	Scottish Home Renewables, Energy Saving Trust
David Stutchfield	Green Homes Network Member



energy saving trust

- **Email:**
GreenInstallerScotland@est.org.uk
- **LinkedIn Group:**
<https://www.linkedin.com/groups/5139242/>
- **Email updates and quarterly newsletter subscription:**
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Thank you for
attending