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Net Zero Salt Cross Garden Village study

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one network

OXFORD TALKS
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Oxford Martin School

Study funded by OXFORDSHIRE COUNTY COUNCIL as part of LEO Local Energy Oxfordshire

About us

Overview

Urbanomy is a subsidiary of EDF Group, specialising in **integrated urban and energy planning.**

We advise local authorities, developers and landowners at the pre-construction stage on how to create net-zero blocks, districts, and communities using low and zero-carbon energy technologies. We adopt a systemic approach to take into account the complexity of Smart Local Energy Systems through spatial analysis and time of use balance. We develop our recommendations using a suite of in-house modelling tools, created and refined over the past decade by EDF's international Research & Development teams.

- **An integrated vision**
- **A human-centric approach**
- **Technology-agnostic offers**
- **An operator-logic perspective at the forefront of innovation**

Research & Development

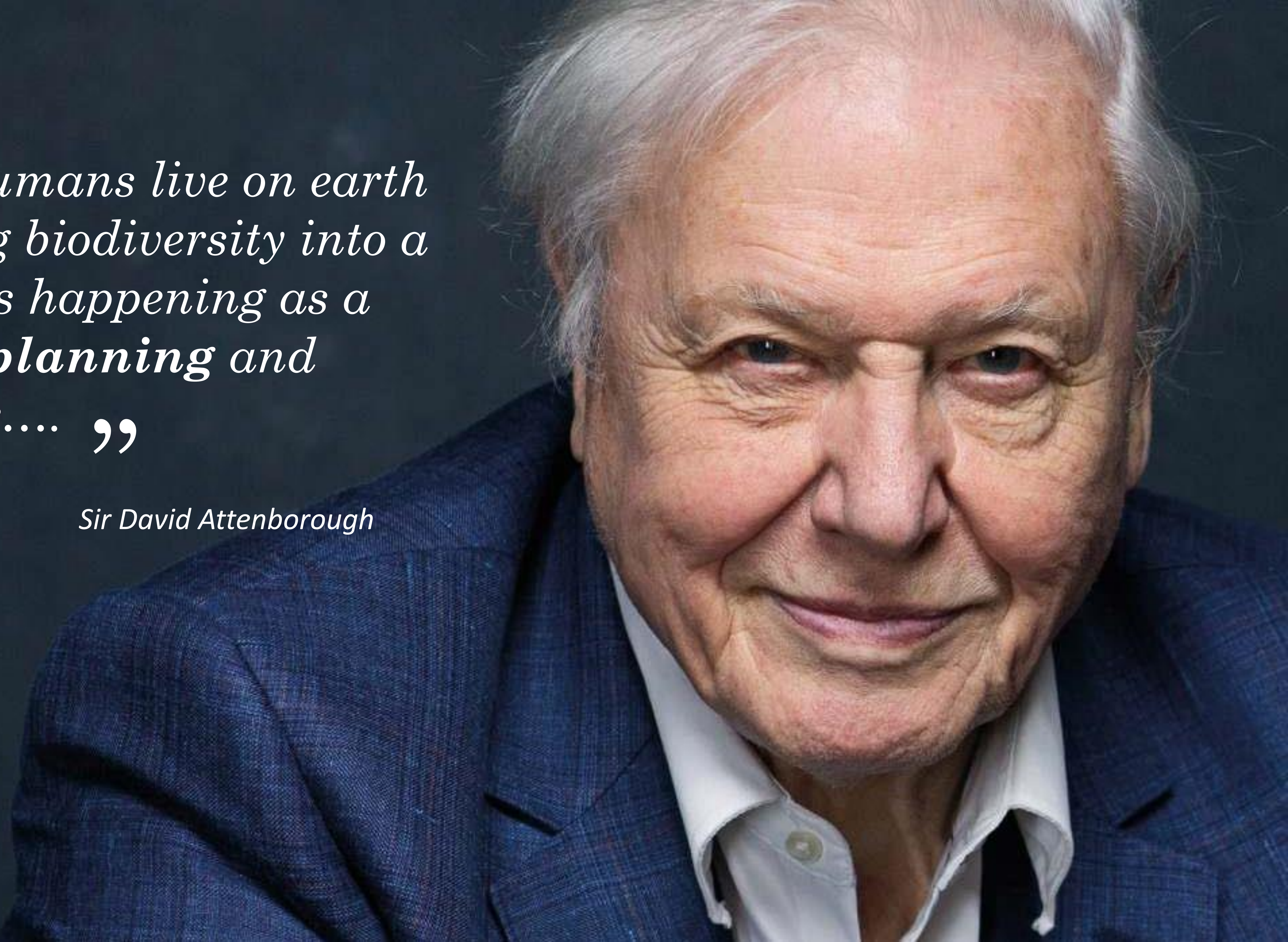
2,100 Researchers across the world

12 centres

3 France
United Kingdom
Germany
Italy
USA
China
Singapore

*“The way we humans live on earth now is sending biodiversity into a decline. This is happening as a result of **bad planning** and **human error**…. ”*

Sir David Attenborough



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Our Vision

NET
ZERO
2050

To accelerate Britain’s transition to net zero through integrated urban and energy planning.

Long-term viability is about taking the right decisions early in the process

Each scale has different challenges

City /Region

- Territorial diagnosis
- Carbon neutral Strategy
- Environmental simulation: Air pollution, UHI, Noise

District

- Energy and Mobility Concepts
- Quality of life and community benefits

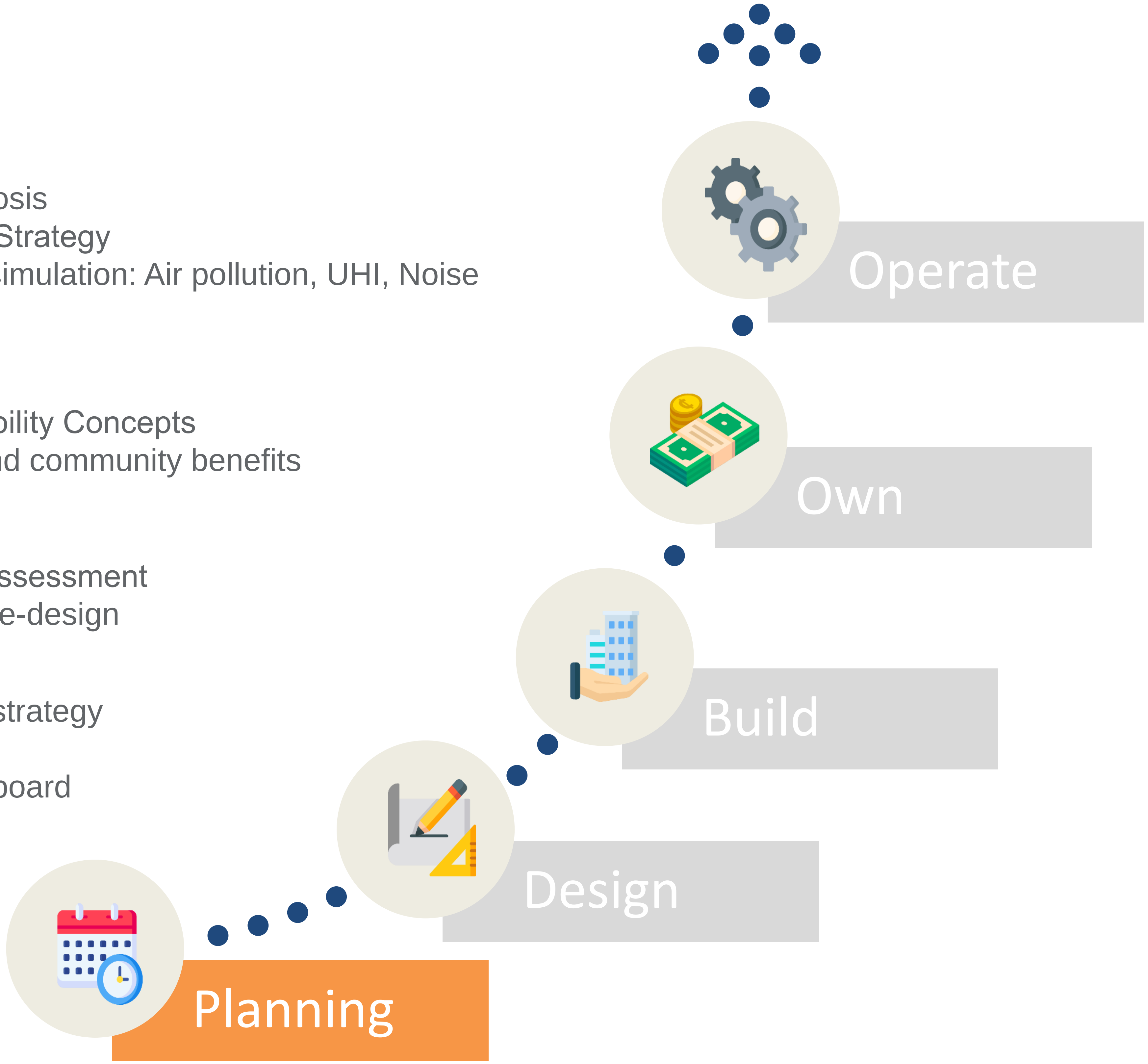
Block

- Micro-Climate assessment
- Infrastructure pre-design

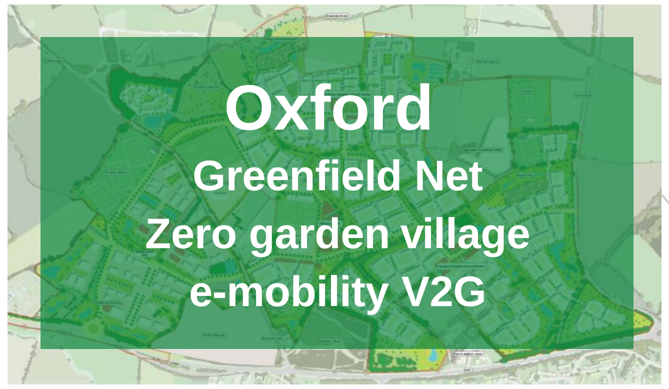
Portfolio

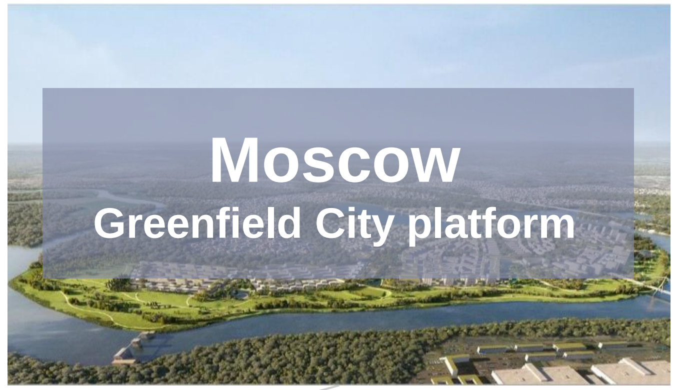
- Decarbonation strategy
- Action plan
- Reporting dashboard

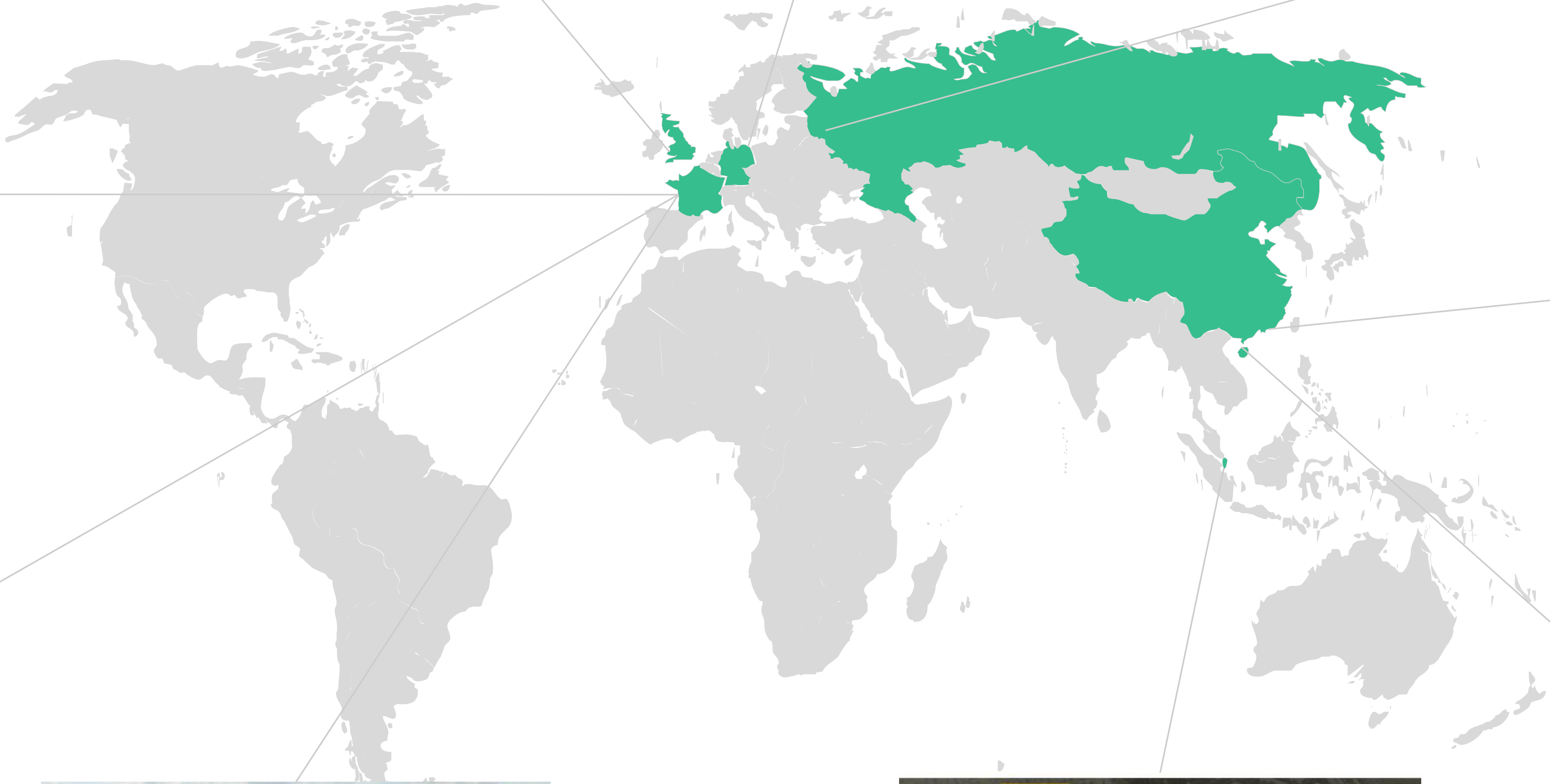
Cost of change

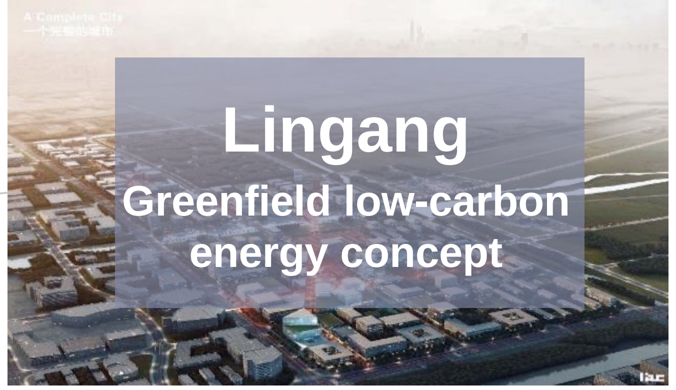


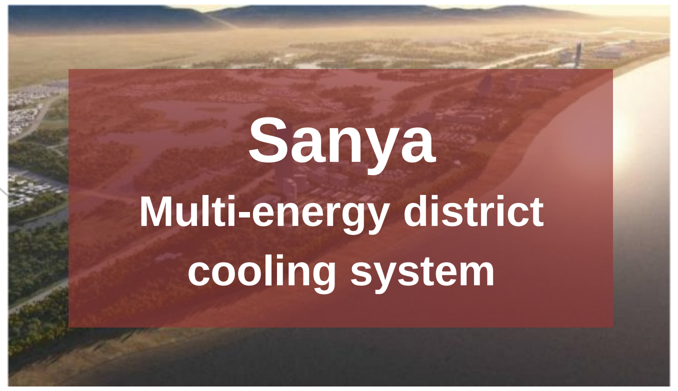
Some examples of what we do











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The Project

Salt Cross Garden Village

- Exemplar garden village development identified in the **West Oxfordshire** Local Plan
- **Smart and Fair Futures** project led by the Low Carbon Hub within the Local Energy Oxfordshire (LEO)
- **2,200 homes**
  Homes to include at least 50% of affordable Rent and Own
- **+1,000** pupil capacity schools
- **1 health centre**
- **1 science park** of more than 40 hectares
- **1 Park & Ride** including 45 charge points

SOURCE - © West Oxfordshire District Council - Area Action Plan

The Ambitions

Salt Cross Garden Village

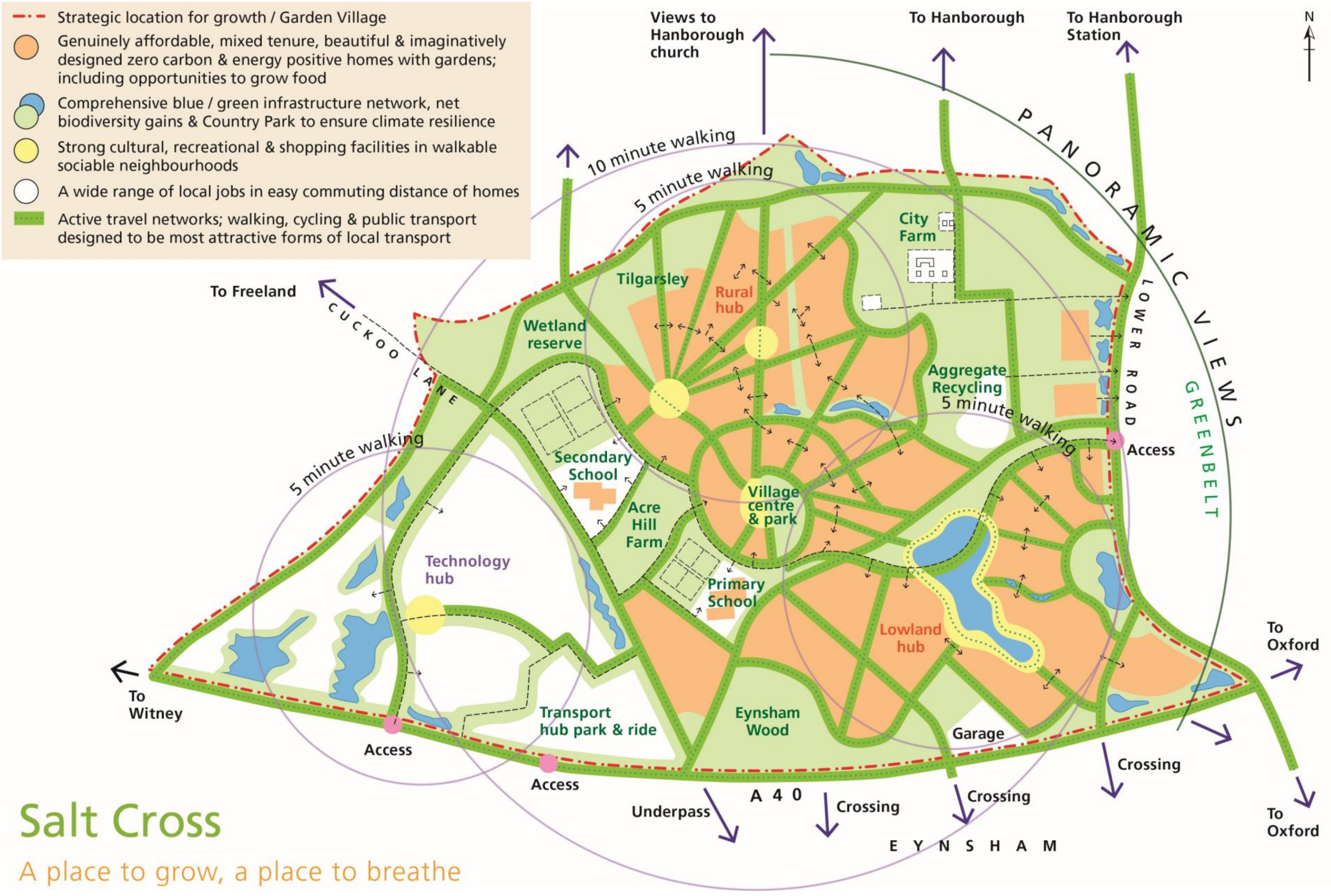
West Oxfordshire published a **draft Area Action Plan** setting up core requirements:

- Net Zero Development
- Low Energy Use in new buildings
- Low carbon energy supply
- No use of fossil fuels on site

Objectives of the study:

- Provide quantifications and insights on local energy system options
- Provide options to minimize the energy use and maximise energy efficiency
- Provide an integrated vision including electrification of transport
- Assess the amount and value of flexibility on-site

WEST OXFORDSHIRE DISTRICT COUNCIL



Source: WODC – Area Action Plan

Project Local Energy Oxfordshire (LEO)

Smart and Fair Futures Eynsham

The study is supporting the Eynsham Smart and Fair Futures project led by the Low Carbon Hub as part of Project LEO (Local Energy Oxfordshire), one of four national demonstrator projects focusing on smart local energy systems.

The study has been conducted in collaboration with Project LEO partners including Low Carbon Hub, the University of Oxford, Oxford Brookes University and Scottish and Southern Electricity Network (SSEN – Lead of the consortium) among others, as well as other local stakeholders West Oxfordshire District Council (WODC)and low carbon community action group Eynsham GreenTEA

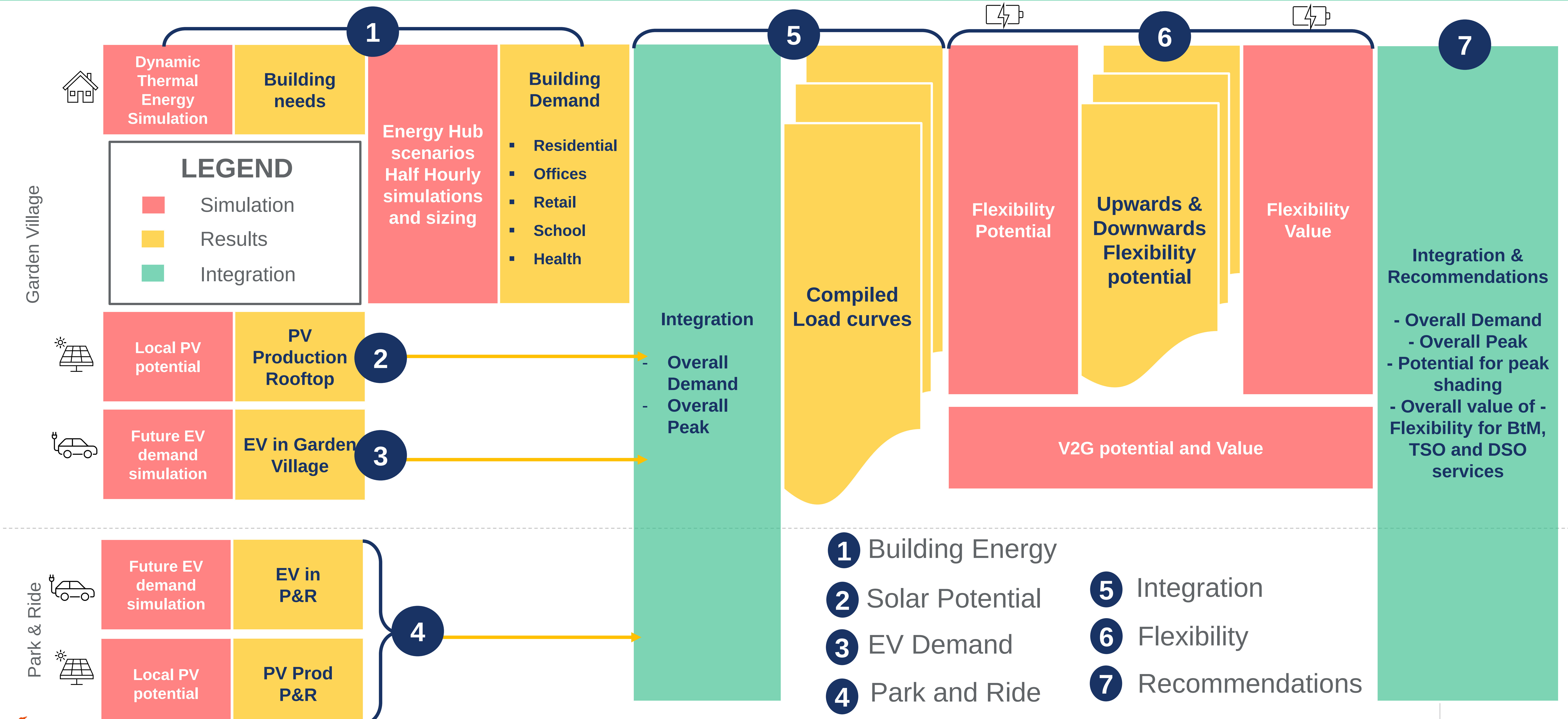
Urbanomy's new study builds on the published Energy Plan (EP) for the area to assess the energy supply and demand, including smart electric mobility, at the garden village development and its impact on the local grid and the wider area.

Funding provided through the Government's modern industrial strategy by Innovate UK, part of UK Research and Innovation.

Transition Eynsham Area (GreenTEA), the local low carbon group and founding community shareholder of the Low Carbon Hub CIC, are chairing the Local Steering Group working closely with the Low Carbon Hub in developing and implementing the smart and fair futures trial. Also on the steering group are representatives of West Oxfordshire District Council and some of the local parish councils.

Source: https://project-leo.co.uk/

Overview of our methodology



Overview of our methodology – Building energy

1

Thermic simulation

Techno Efficiency

Definition of building typologies and characterisation of fabric and design

Calculation of Energy Needs for the 4 main uses

Calculation of load curve of final energy demand

Building typologies are first defined for the expected types of buildings to be built in the new development, including residential and non-residential buildings. These typologies will be overlayed with their thermal characteristics, fabric assumptions, and orientation to inform the calculations.

The **energy needs** for the 4 main uses: <u>heating, air conditioning, domestic hot water and unregulated electricity</u>, will then be assessed and represented as a load curve. Further study calibrate this assessment even further, for example amending the heating setpoint and air conditioning temperatures, as well as the ventilation specifications.

This is followed by an assessment of **final energy demand** for the various chosen technologies for heating, domestic hot water and cooling, represented as a load curve. 3 scenarios are defined for the combination of these technologies in each building typology, allowing for the preferences and ambitions of the stakeholders to be collated.

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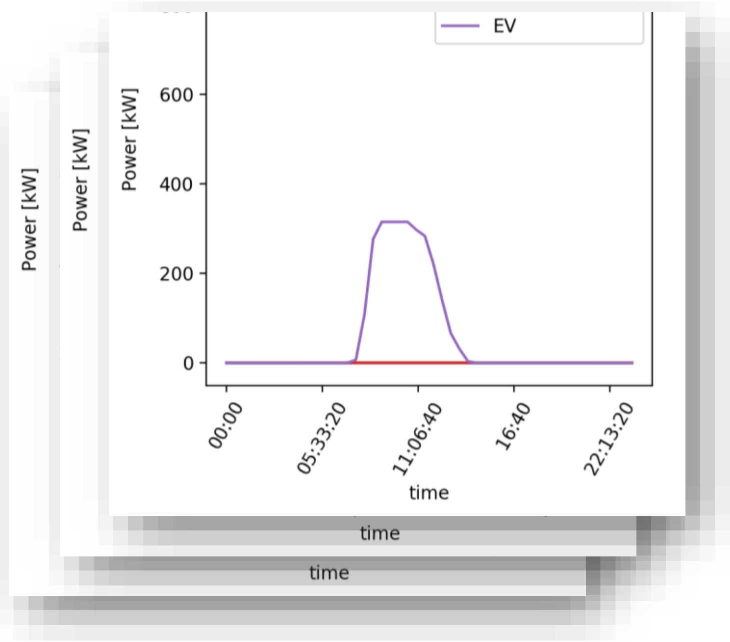
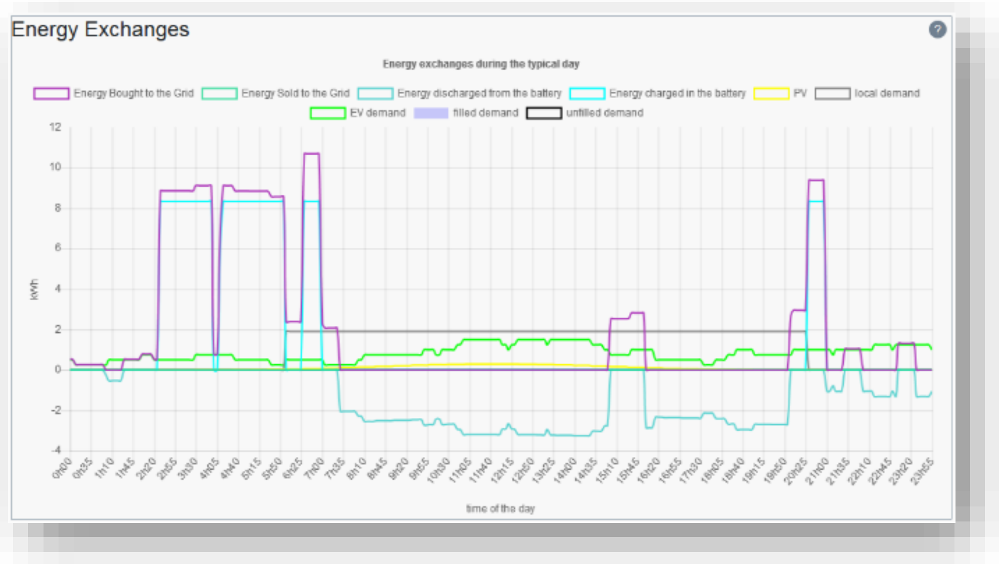
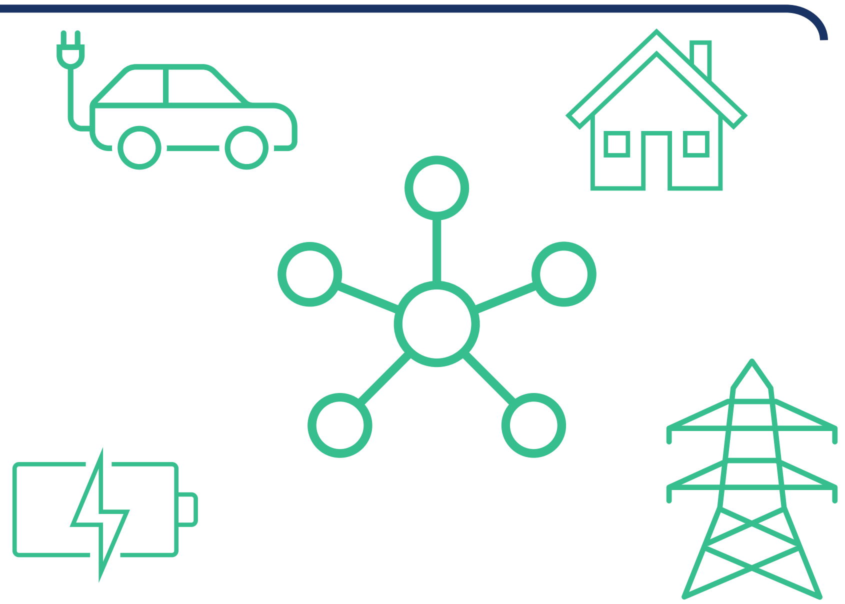
Overview of our methodology – Electric Vehicles

3







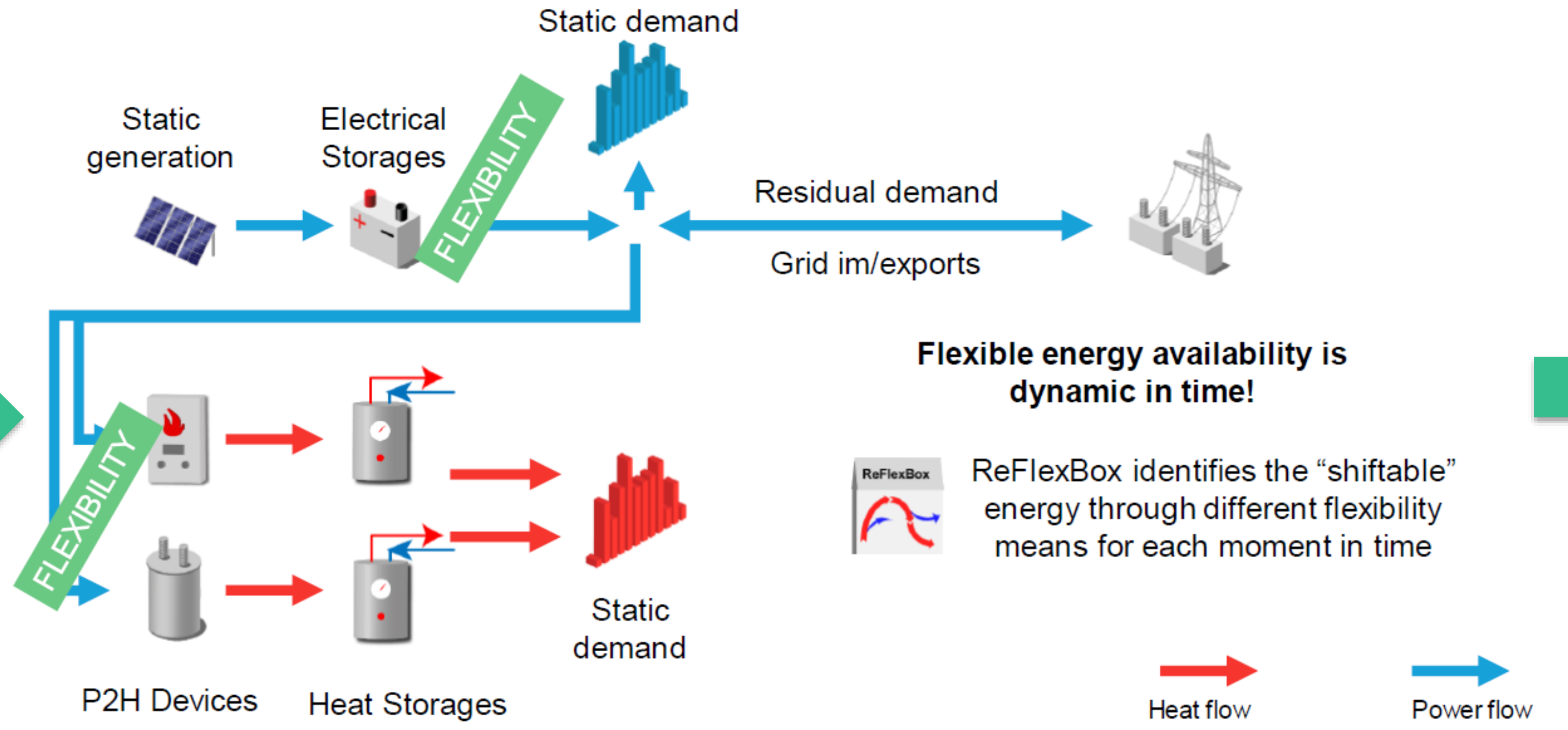
EVSE infrastructure for the new development will be assessed in terms of number and types of charge points to be installed.

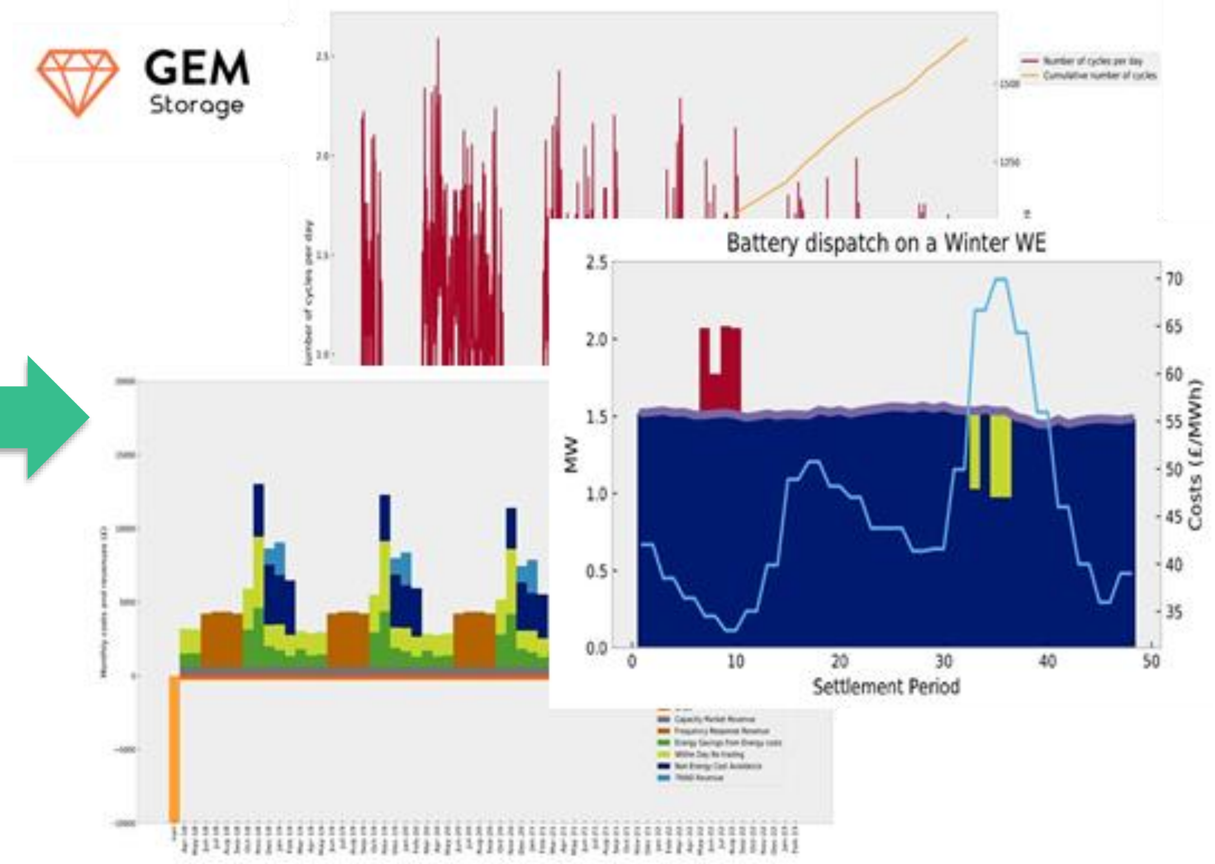
Evaluation of EV demand: From the EV charge point needs evaluation, the total electricity demand for EVs is assessed through a database of real world profiles of electricity demand.

Solar canopy and parking energy system assessment to provide a combined load curve for a parking facility. This step uses an advanced optimisation toolbox allowing us to assess the PV potential for solar canopies as well as the demand from parked EVs.

V1G/V2G recommendations and potential for the EV parked at the new development. The potential for local flexibility and services to the local grid is assessed through an optimisation tool, which allows us to conduct a detailed evaluation of the benefits of V1G and V2G, both in terms of revenues and reduction of constraints for the local grid.

Overview of our methodology – Flexibility





Compilation of the outcomes of the energy and mobility studies of phase 1. Creation of an overall load curve for the energy demand and local energy production.

Modelling and analysis of flex available throughout various assets (batteries, cooling, HP, …) The tool used for this step is modelling the whole energy system through the various technologies implemented in the buildings (HP, storage, …), for the PV production and for the EV demand and will analyse the load curve to provide a potential of flexibility available.

Quantification of flex value for specific services. From the quantification of the flexibility done in the previous step, we analyse the potential revenues for the delivery of 'behind the meter' or 'in front of the meter' services. A focus will be done on the DSO services defined by SSEN in LEO.

Disclaimer and Copyright

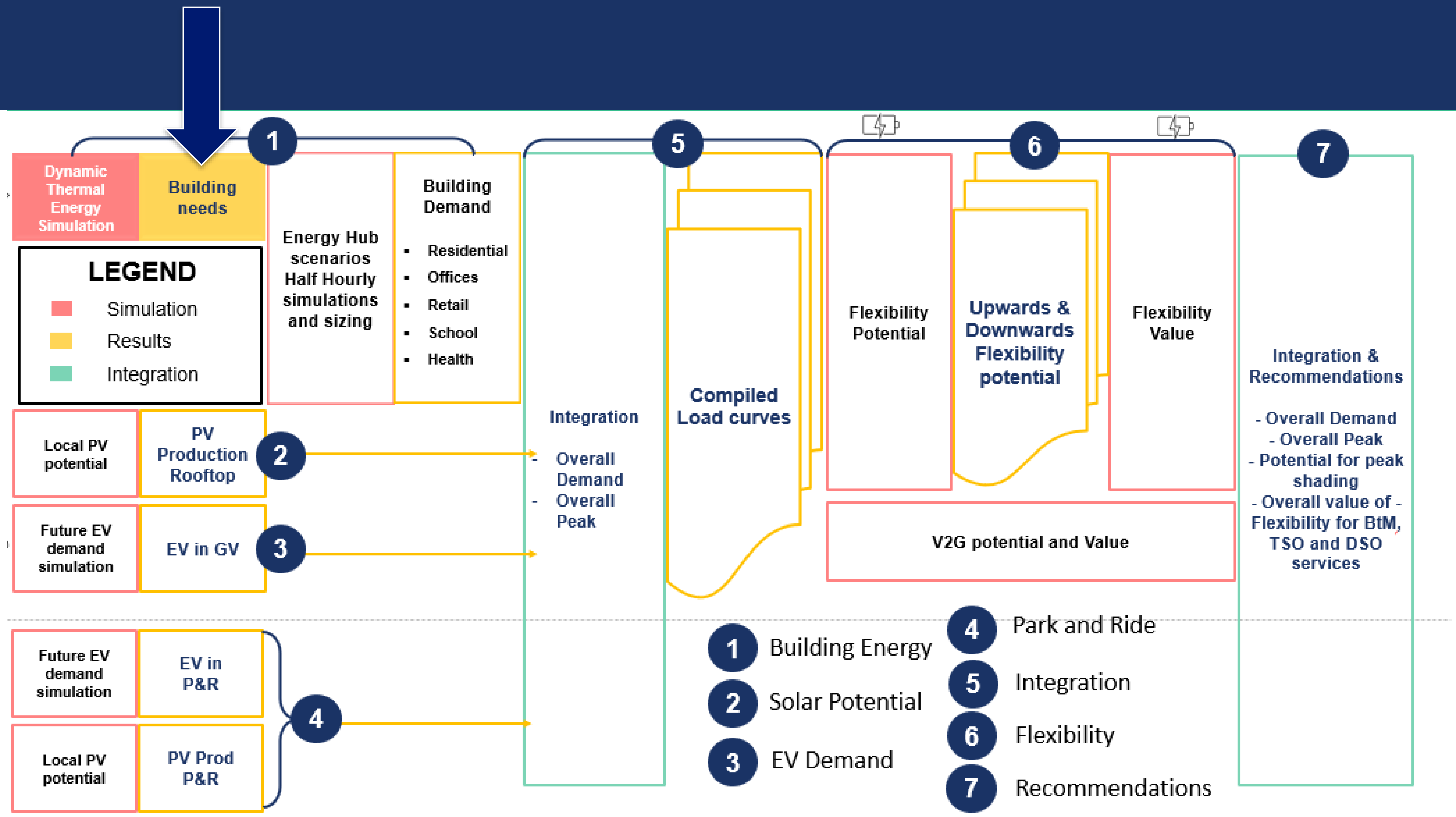
The results presented in this study reflect the outcomes from simulations conducted by Urbanomy and are supporting a work in progress in the planning process of the Salt Cross Garden Village.

The outcomes might change according to evolutions in the requirements and design of the area.

For any requirement, please contact contact@urbanomy.io

SOURCE - © West Oxfordshire District Council - Area Action Plan

1.1. Energy needs in the buildings



Building mix assumptions

1595 buildings

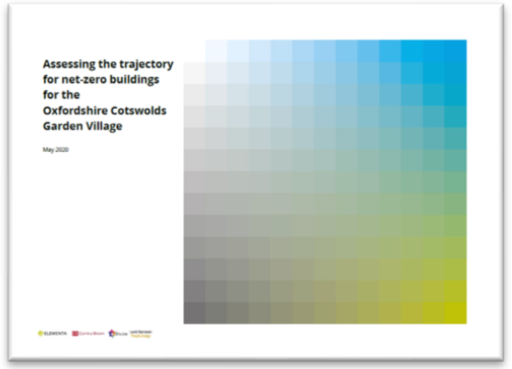
- Terraced Houses (133,000 sqm): 2 storeys **1554**
  - *Terraced Houses (2 beds dw.) : 65 m²* *454*
  - *Terraced Houses (3 beds dw.) : 90m²* *748*
  - *Terraced Houses (4 beds dw.) : 105m²* *352*
- Med-Rise (33,000 sqm): 5 storeys **12**
  - *1-bed dwellings: 45m² (35 per building)* *420*
  - *2-bed dwellings: 65m² (22 per building)* *264*
- Offices (40,000 sqm): 3 storeys **10**
  - *10 buildings of equal size*
- Specialist offices (40,000 sqm): 3 storeys **10**
  - *10 buildings of equal size (or 9 in the Data Centre scenarios)*
- Schools (8,500 sqm): 2 storeys **2**
  - *Primary School: 3563m²*
  - *Secondary School: 5600m²*
- Retail (1,500 sqm): 3 storeys **6**
  - *5 buildings of equal size*
- Health (460 sqm): 3 storeys **1**
  - *1 building*

Assumptions in coherence with the Area Action Plan of West Oxfordshire District council, and in line with Elementa Energy Study.

Salt Cross Garden Village – Area Action Plan (AAP)
www.westoxon.gov.uk

Summary of the demand scenario

Baseline scenario was established based upon assumptions from the Elementa study (2020 - AAP) scenario 4.2.



Typology	Fabric	Heating and DHW system	Energy Needs Modelling Considerations
Terraced	U values: Ultra low standard Floor: 0.08 Wall: 0.13 Roof: 0.10 Window: 0.8 Thermal Bridge: 0.04 Ventilation: 90% recovery Airtightness: <1m³/hr.m²	Air Sourced Heat pump (individual or communal) with flow and return temperature 65○C /50○C	90m² dwelling size, N/S and E/W orientations, and standard UK behaviours
Med-Rise			65m² dwelling size and standard UK behaviours
Retail			Heat recovery from fridge installations, and generic behaviour for a retail unit
Health Centre			DHW similar to office behaviours, and others based on generic health units
School			Based on UK school scheduling.
Office		Heat pumps with low flow and return temperature 45○C /40○C fed from ambient loop or ground source array	Standard UK practices for offices
Specialist Office			Standard laboratory activities – Adapted from Begbroke Science Park case.

Climatisation

- Only in office, specialist and data center

Semi-instantaneous DHW

- for every typology

Local weather condition

- timeseries of 2020, hourly values
  - Min -5°C
  - Max 32°C

Principle of the energy need assessment

The assessment is based on the simulation of the behavior (thermal exchanges between the in-out door), by using a Dynamic Thermal Energy simulation

Roof
U: 0.1 W / m²K

Reducing the set temperature during the night

Ventilation on 24/7

Floor
U: 0.08 W / m²K

Double flow controlled mechanical ventilation

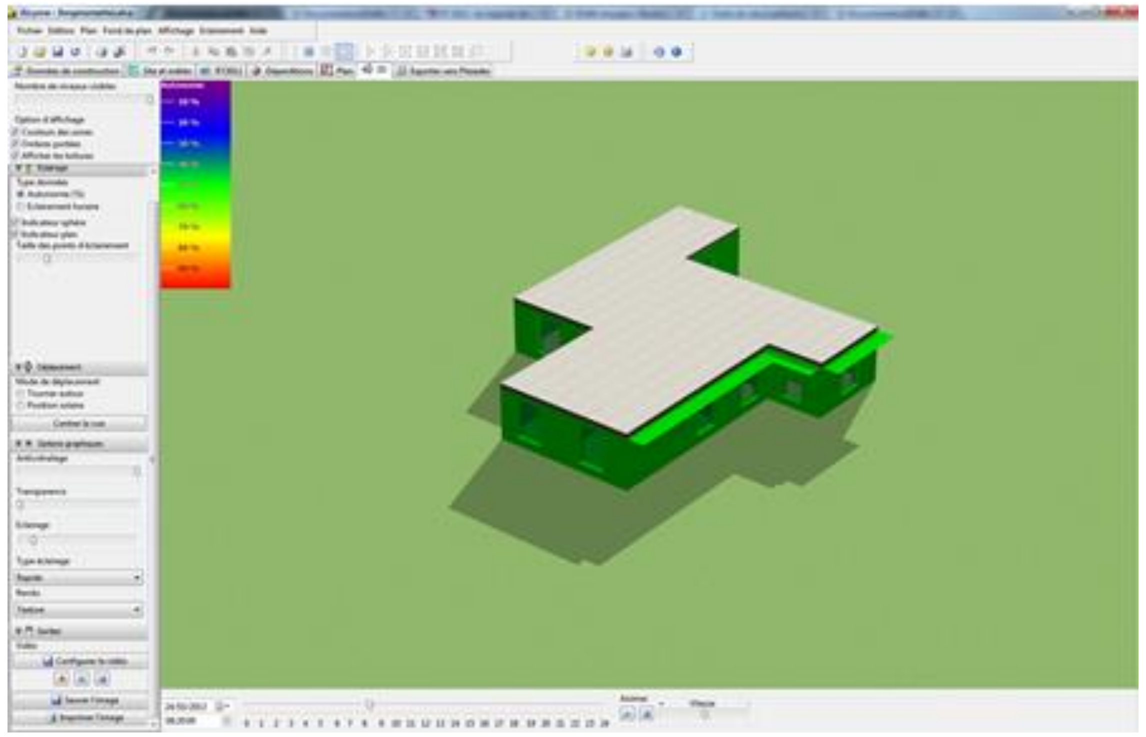
Window:
30% façade (15% total)
U: 0.8 W / m²K

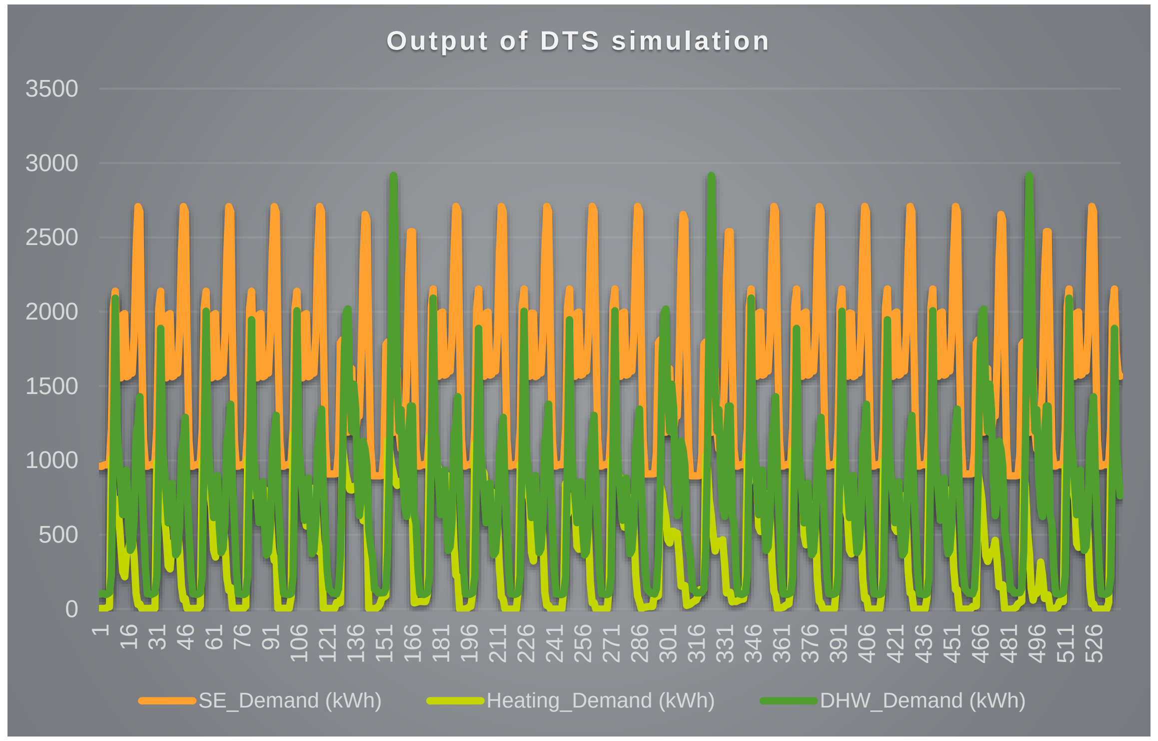
Equipped with air conditioning (offices)

Set point temperature: 18 ° C

Set point cooling temperature: 24 ° C

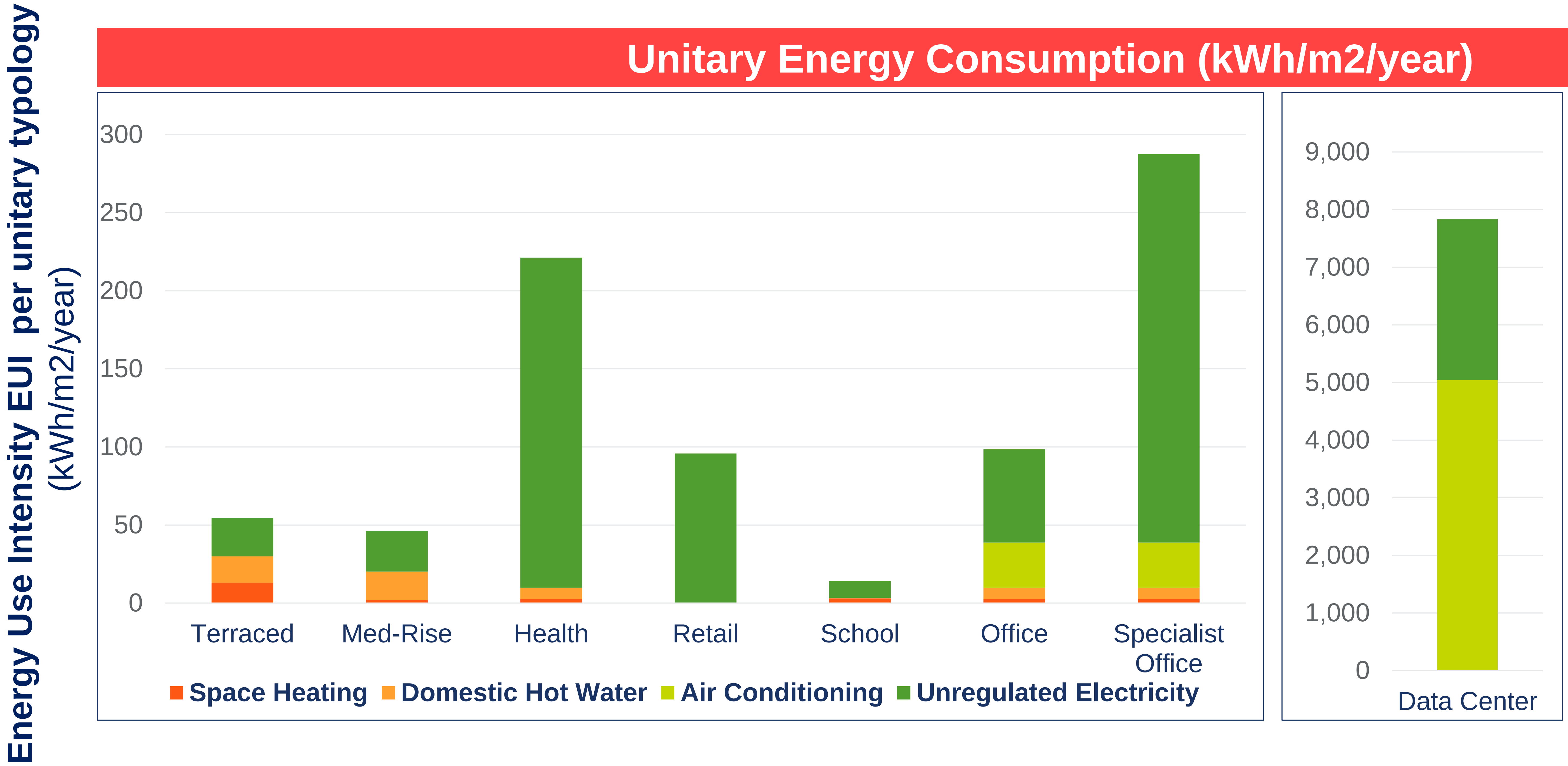
Wall
U: 0.13 W / m²K





The geometry and the thermal characteristics of the components are considered.

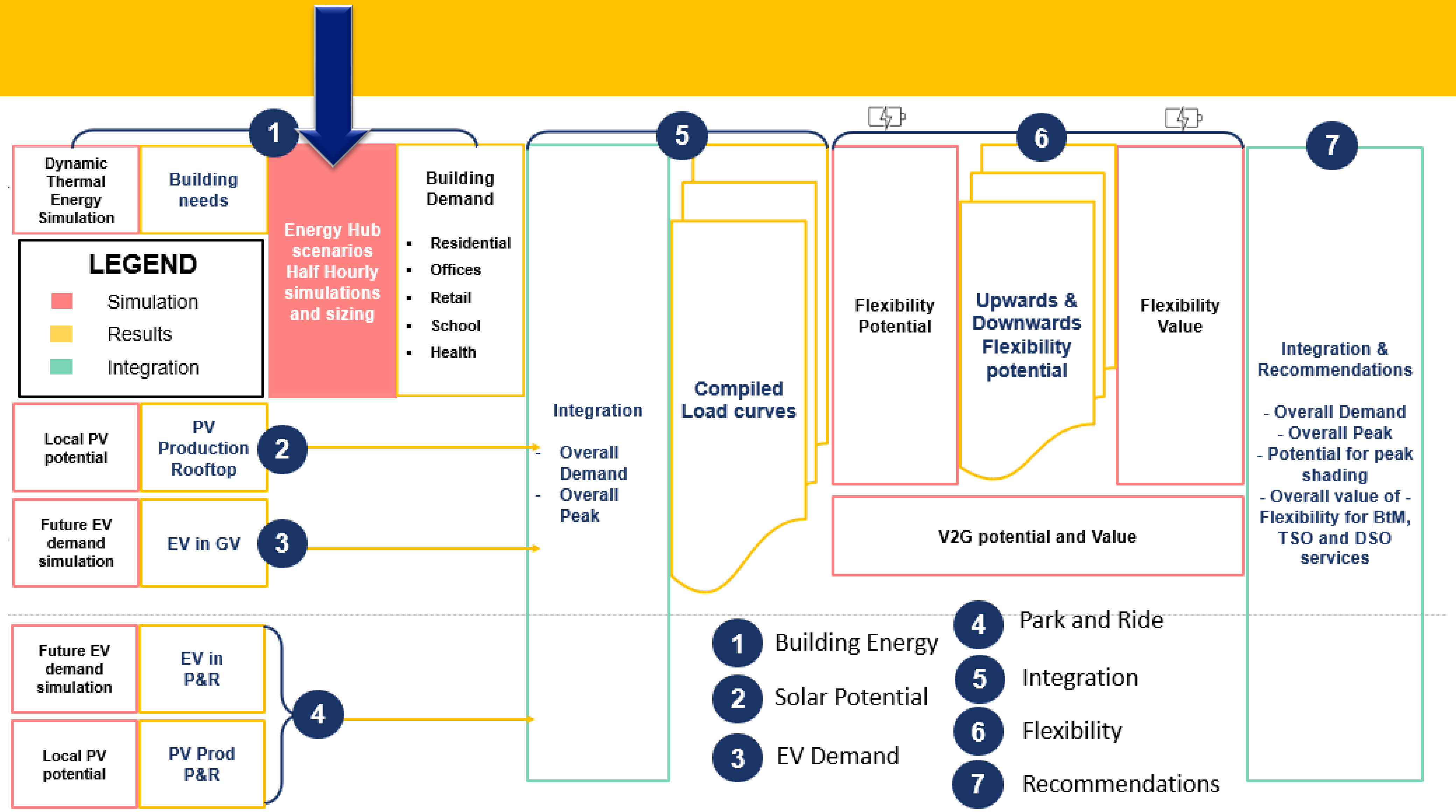
Unitary Energy Consumption by Typology



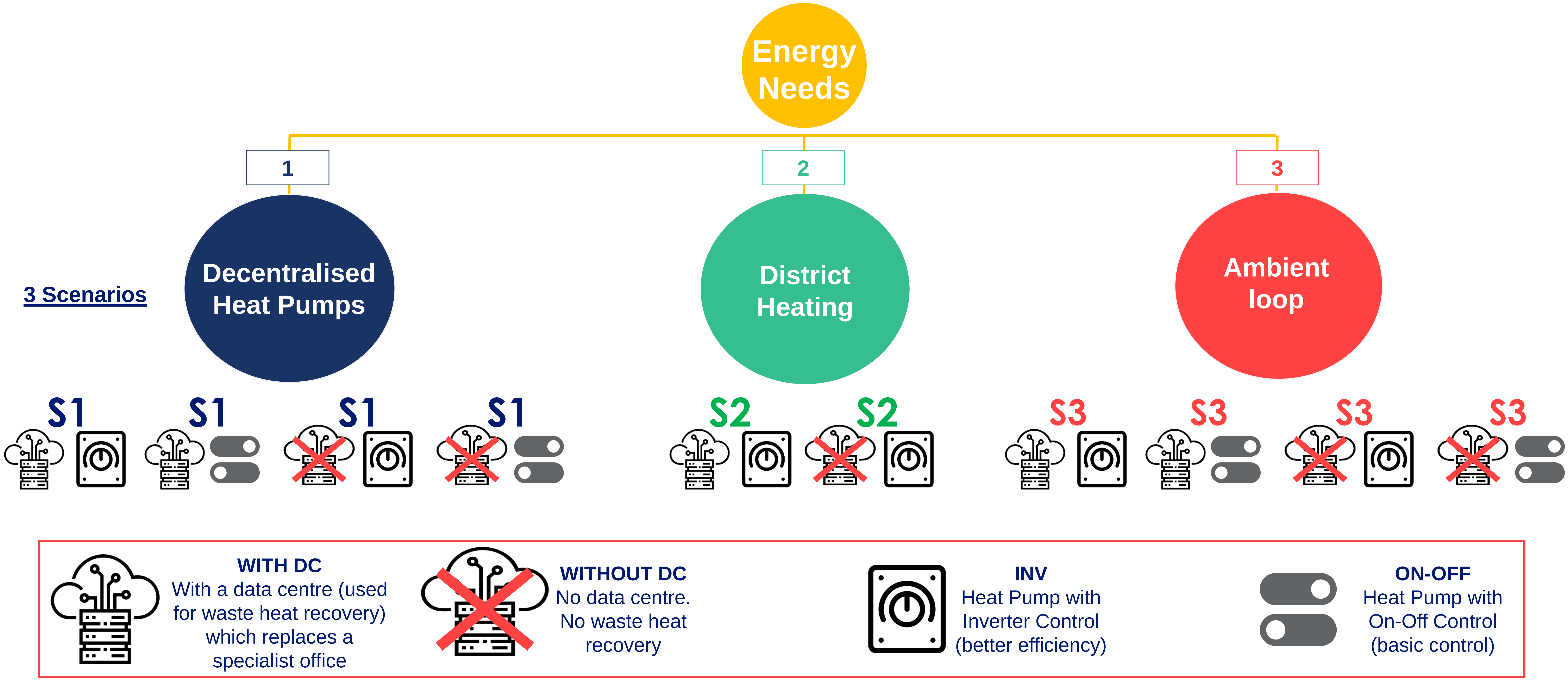
- ✓ The Dynamic Thermal Energy Simulation has been conducted on all typologies with the target of high thermal standard.
- ✓ The target of < 15 kWh/m2.yr of space heating demand is met for every typologies
- ✓ Very high standard has been applied for the building fabric and the thermal insulation, including thermal bridges simulation.
- ✓ Thermal uses (SH and DHW) results are very low proving the ability to reach ambitious targets, however, unregulated electricity and AC needs (not considered in SAP) are too high to reach the targeted EUI.

Results reflects the level of information available at the time of the simulations and will be updated according to the latest updates in planning process

1.2. Energy scenarios



In a nutshell : 3 main energy scenarios with variations

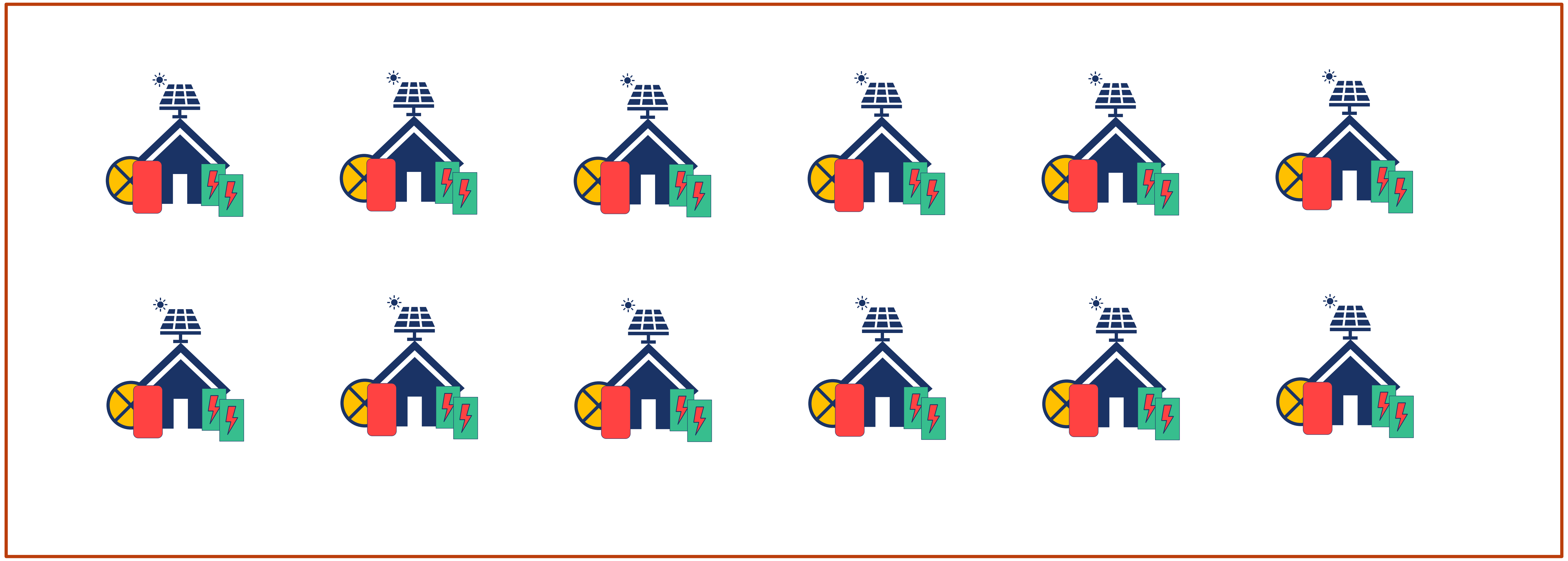


Scenario 1 – Decentralised production system – Air/Water heat pumps

How does scenario 1 work?

- Each building is independent
- The space heating (SH) and the domestic hot water (DHW) are supplied by an air/water heat pump at 65°C
- A DHW storage is installed close to the heat pump to ensure potential flexibility which could be needed based on electricity prices, PV production and to limit quick load variation of the heat pump
- In summer, the heat pump can supply the cooling needs (if reversible heat pumps are used) or an additional air conditioning system is installed
- This scenario includes 4 variations : with data centre + with Heat Pump with Inverter Control, with data centre + with Heat Pump with on-off control, without data centre + with Heat Pump with Inverter Control, and without data centre + with Heat Pump with on-off control

SIMPLE REPRESENTATION | SCENARIO 1



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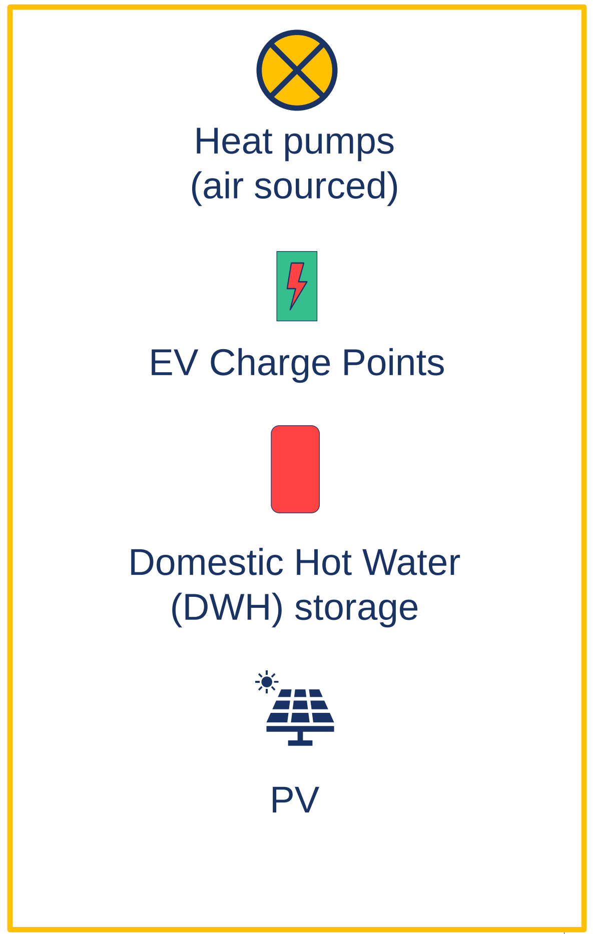
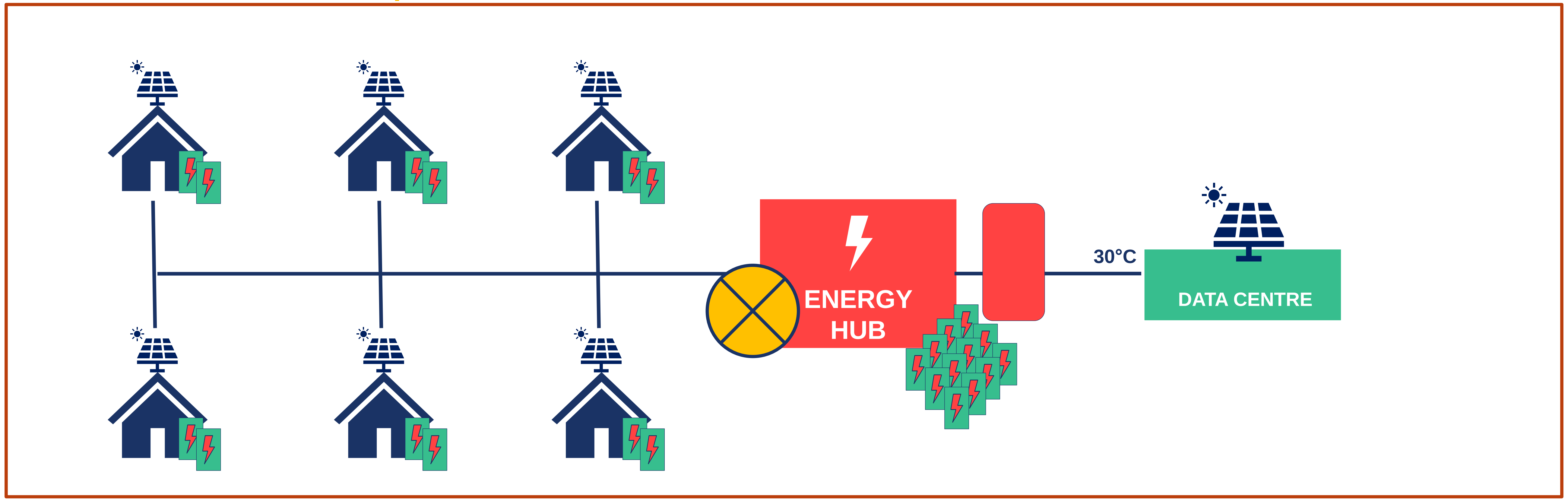


Scenario 2.a - Heat network - Heat recovery from data centre and central heat pump

How does scenario 2.a work?

- This scenario assumes a central energy hub with the inclusion of a data centre in the business park as central production units for the district
- A centralized heat pump (65°C) is installed in the energy hub
- The waste heat from the data centre is used to preheat the water to around 30°C
- A low temperature heat network (supply 65°C – return 40°C) is used to connect all the buildings to the energy hub
- DHW buffer tanks are installed in the building or in the dwellings to ensure flexibility in the system
- For cooling, the option to use the heat pump in a reversible way (or to install an electric chiller) with the network as a cooling network needs to be discussed in comparison to installing electrical climatization systems (because of the strong correlation with PV production and cooling needs).
- This scenario does not include variations : Heat Pump with Inverter Control only for the Energy Hub;

SIMPLE REPRESENTATION | SCENARIO 2.a



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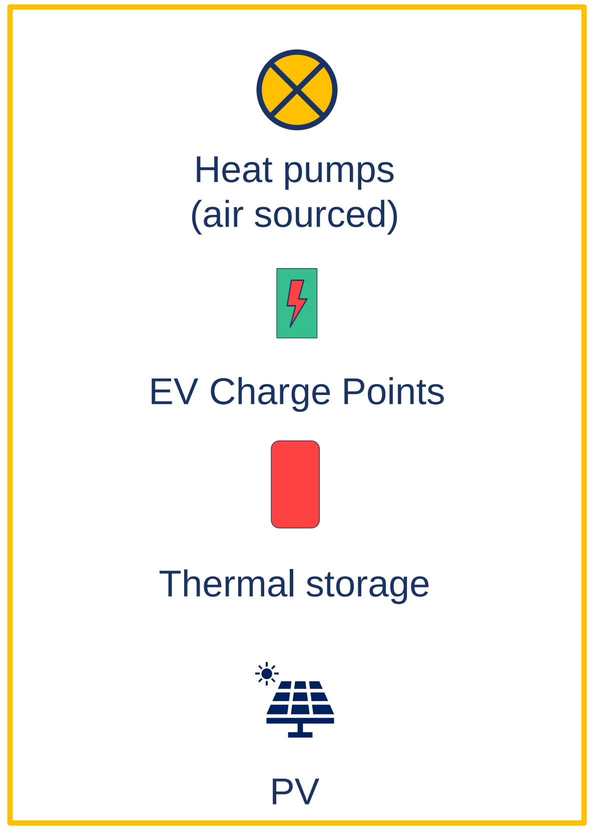
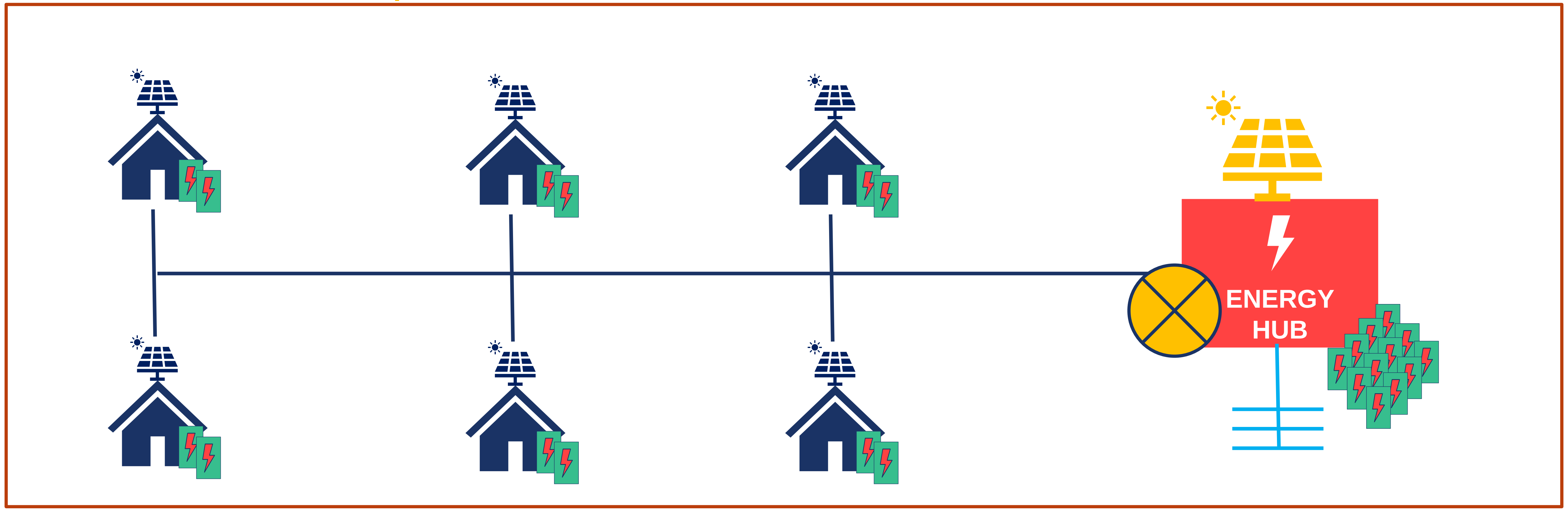


Scenario 2.b - Heat network - Solar and shallow geothermal production

How does scenario 2.b work?

- The energy hub is the central production unit for the district
- Solar thermal panels are installed on the roof and/or around the energy hub according to the needs
- A centralised heat pump (65°C) is installed in the energy hub
- A borehole system is installed underground below the energy hub and/or below the solar thermal field according to needs. The geothermal borehole system is used as heat source for the heat pump and seasonal storage for the solar thermal production
- A low temperature heat network (supply 65°C – return 40°C) is used to connect all the buildings to the energy hub
- DHW buffer tanks are installed in the building or in the dwellings to ensure flexibility in the system
- For cooling the option to use the heat pump in a reversible way (or to install an electric chiller) with the network as a cooling network needs to be discussed in comparison to installing electrical climatization systems (because of the strong correlation with PV production and cooling needs)
- This scenario does not include variations : Heat Pump with Inverter Control only for the Energy Hub;

SIMPLE REPRESENTATION | SCENARIO 2.b



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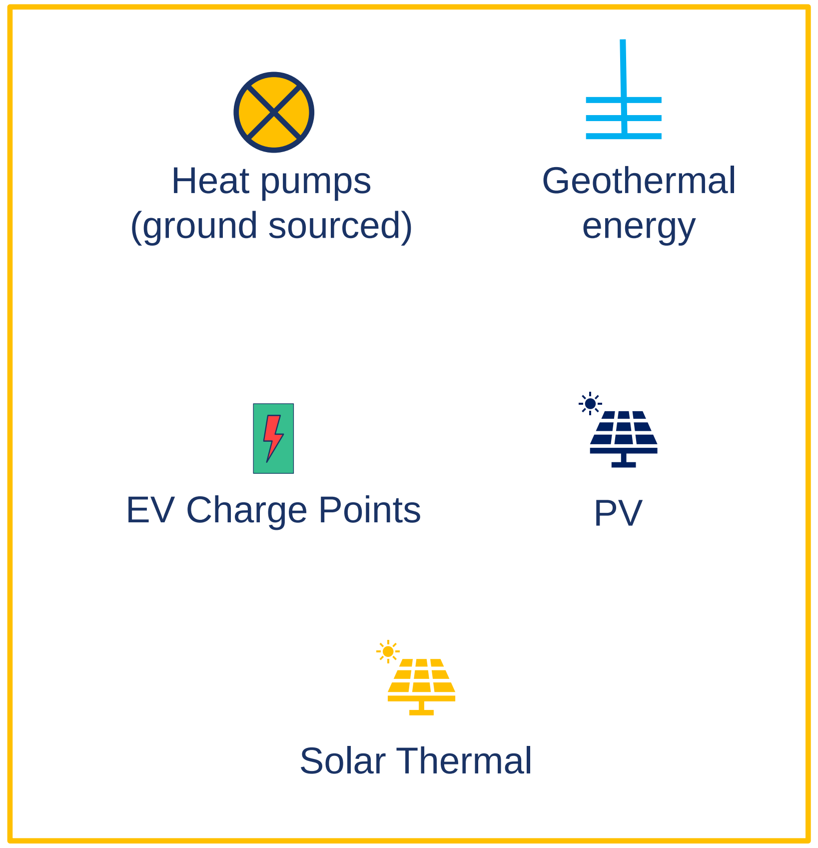
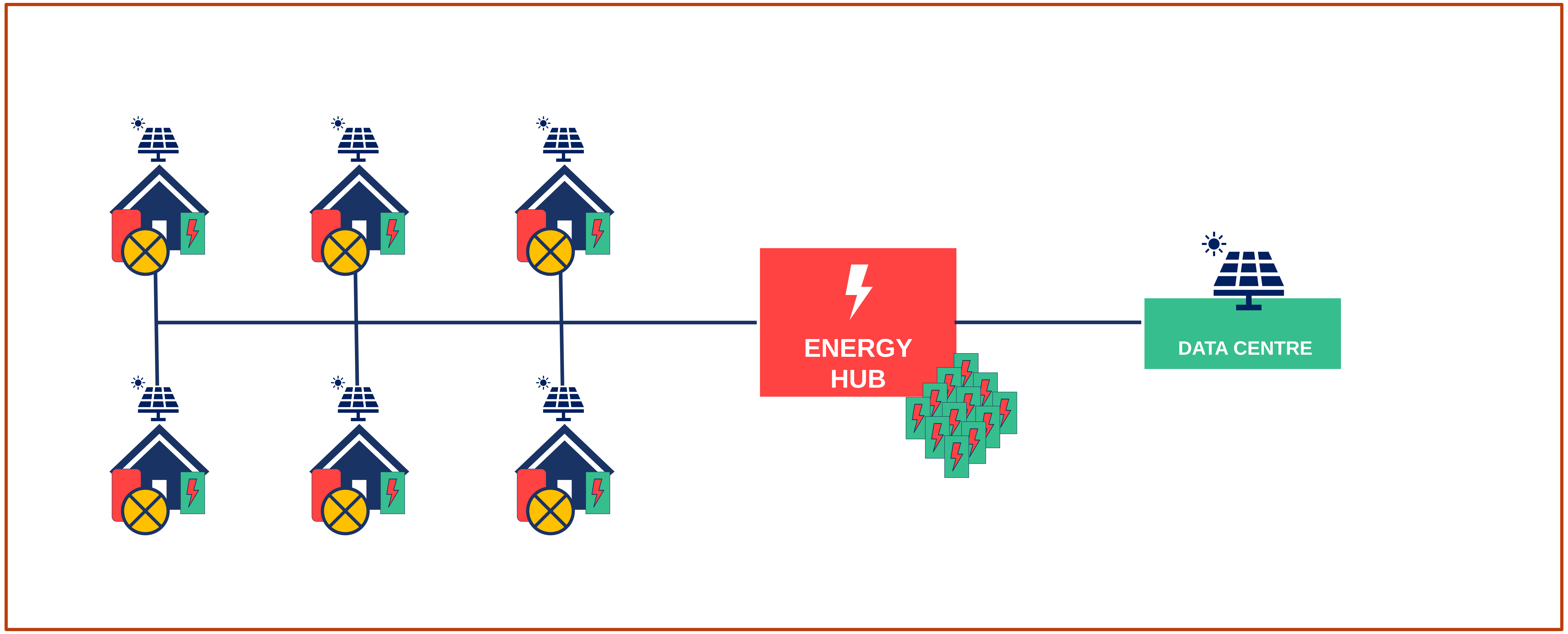


Scenario 3.a - Production system – Water / water heat pumps on ambient loop supplied by the data centre

How does scenario 3.a work?

- The waste heat from the data centre is used to preheat the water and supply an ambient water loop (25°C – 15°C)
- All buildings are connected to this ambient loop
- For each building, heat pumps using the ambient loop are installed as a heat source
- According to the use of the building and level of matching temporality of the heating and cooling needs, simple heat pumps, reversible heat pumps or thermo-refrigerating pumps will be installed
- Additional small heat-pumps will be installed to produce instantaneous DHW at dwelling levels
- This scenario includes 2 variations : with Heat Pump with Inverter Control and with Heat Pump with on-off control

SIMPLE REPRESENTATION | SCENARIO 3.a



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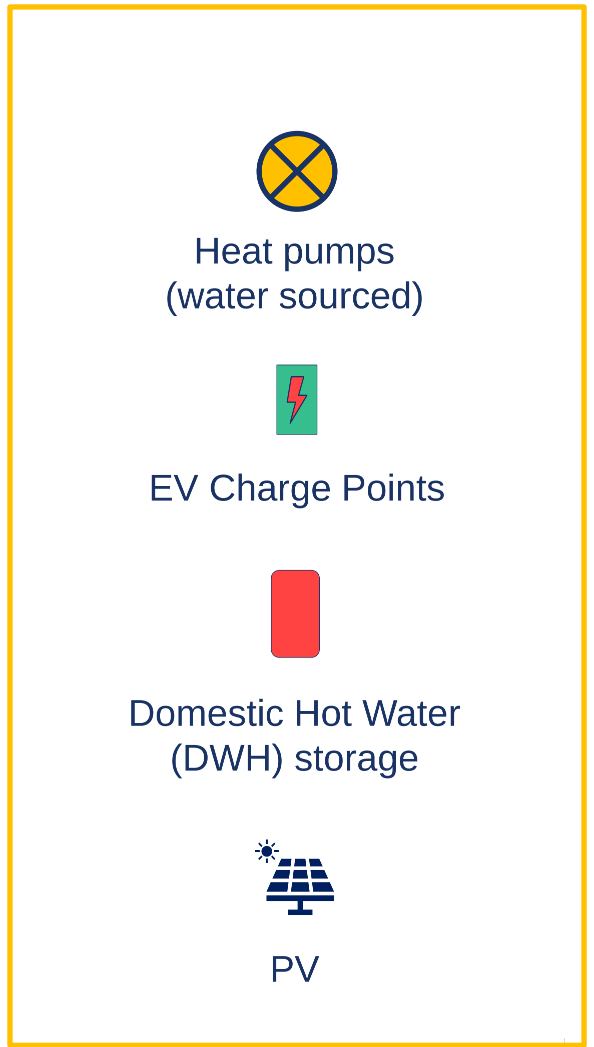
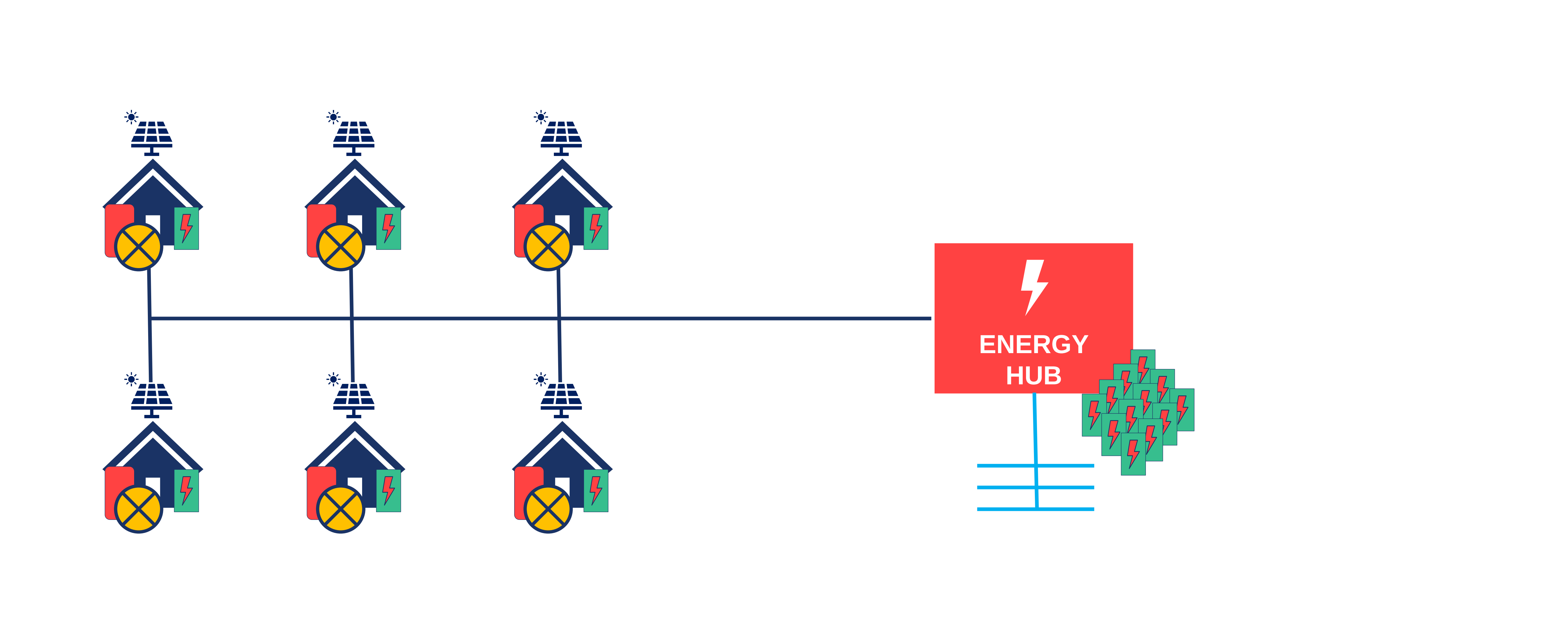


Scenario 3.b - Production system – Water / water heat pumps on ambient loop supplied by borehole system

How does scenario 3.b work?

- Below the energy hub, a geothermal borehole system is supplying an ambient water loop (25°C – 15°C)
- All building are connected to this ambient loop
- At each building, heat pumps using the ambient loop are installed as a heat source
- According to the use of the buildings and level of matching temporality of the heating and cooling needs, either simple heat pumps, reversible heat pumps or thermo-refrigerating pumps will be installed
- Additional small heat-pumps will be installed at the dwelling level to produce instantaneous DHW
- This scenario includes 2 variations : with Heat Pump with Inverter Control and with Heat Pump with on-off control

SIMPLE REPRESENTATION | SCENARIO 3.b



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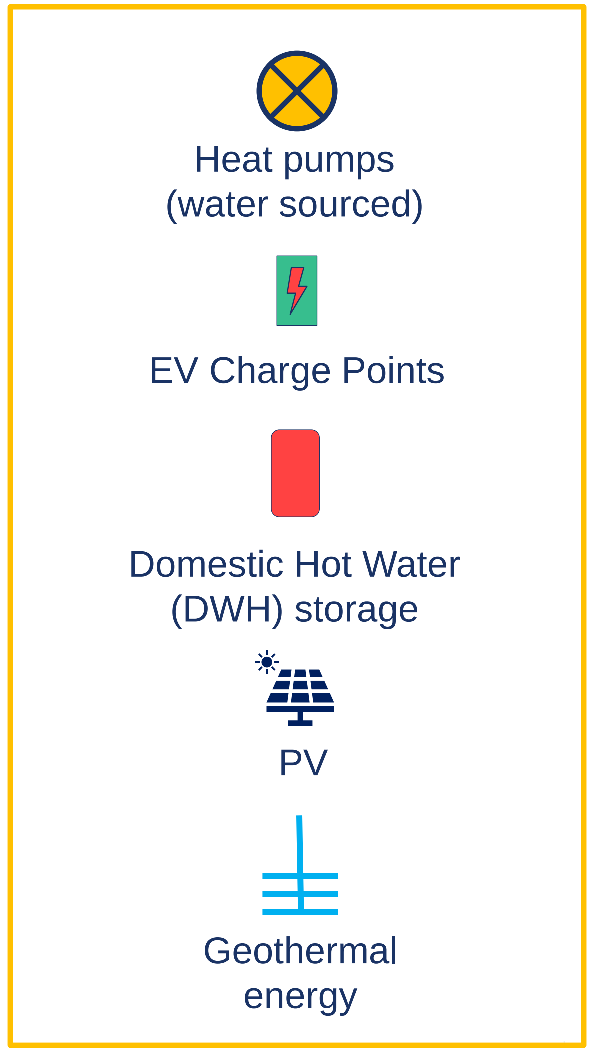
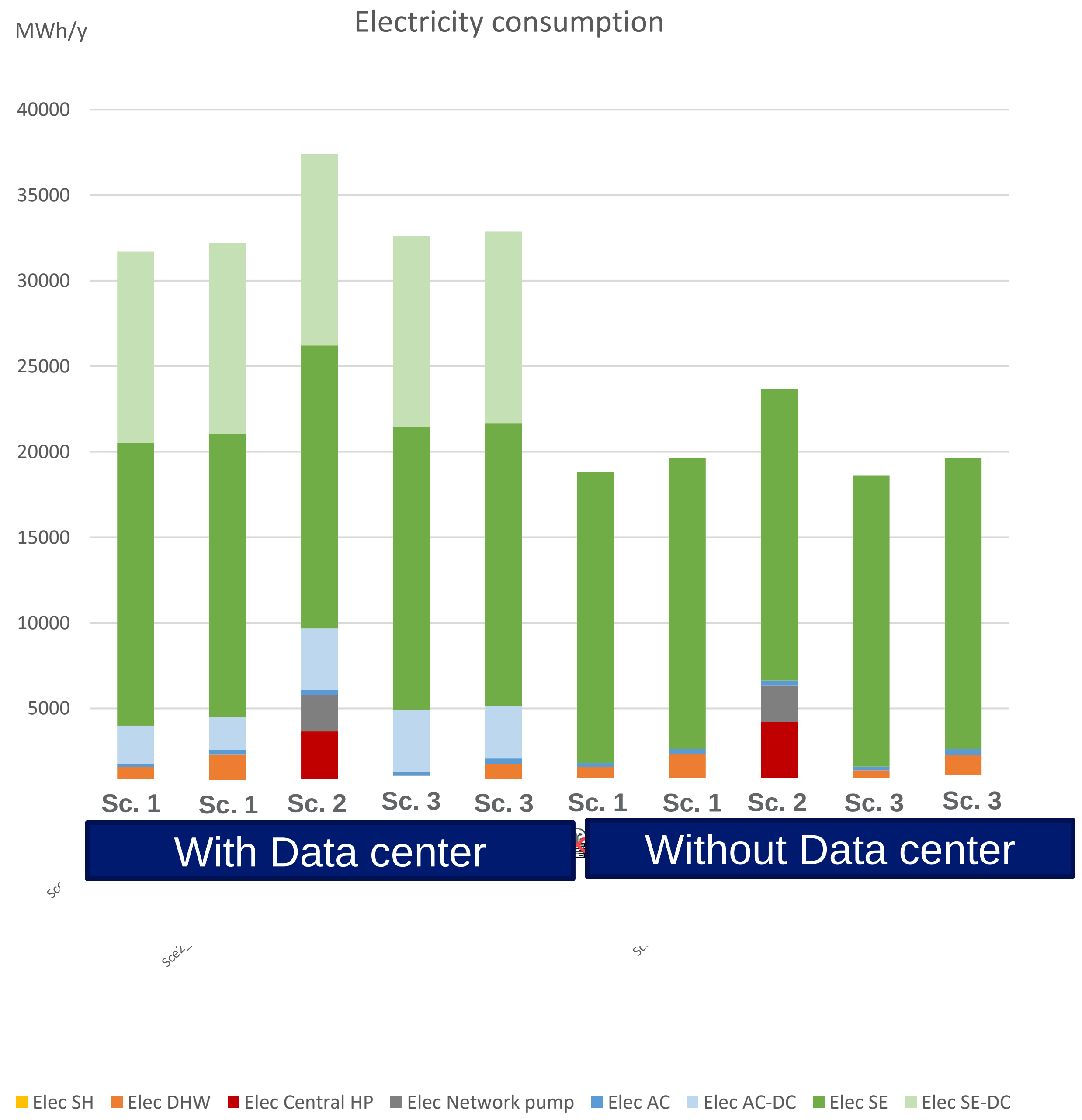


Scenario comparison – annual values



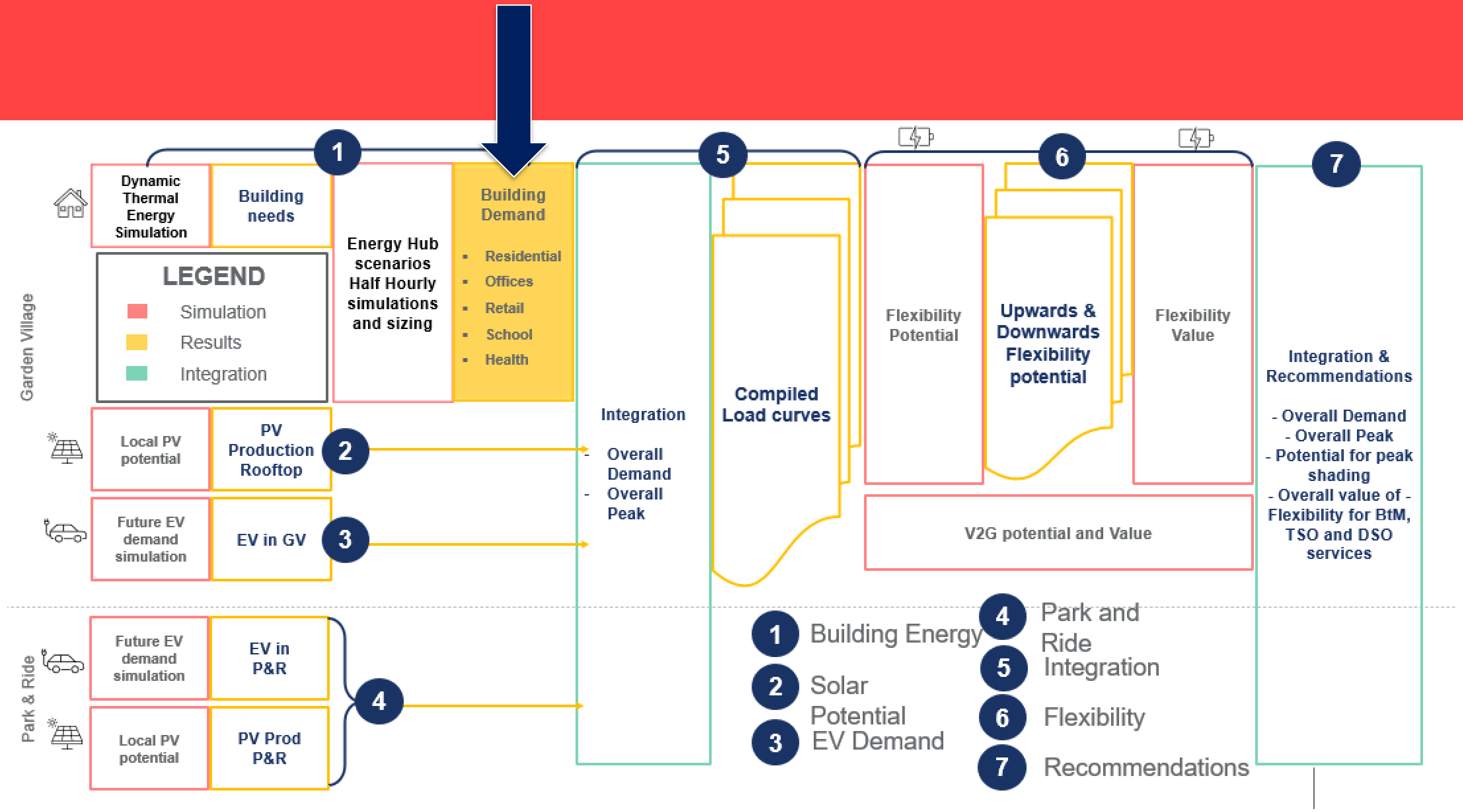
Concerning the final energy consumption of the buildings given the described scenarios (Data centre excluded) :

- Use of **inverter-controlled technologies** instead of ON/OFF → **30 to 40 % electricity savings**

  Use of **ambient loop maintained at 20°C by data centre** or other source → **15 to 30 % electricity savings**

- Use of **ambient loop maintained at 12°C by geothermal energy** → **< 1% electricity savings**
- Use of **70°C district heating** → **+ 130 to 150% electricity consumption (due to high thermal losses)**

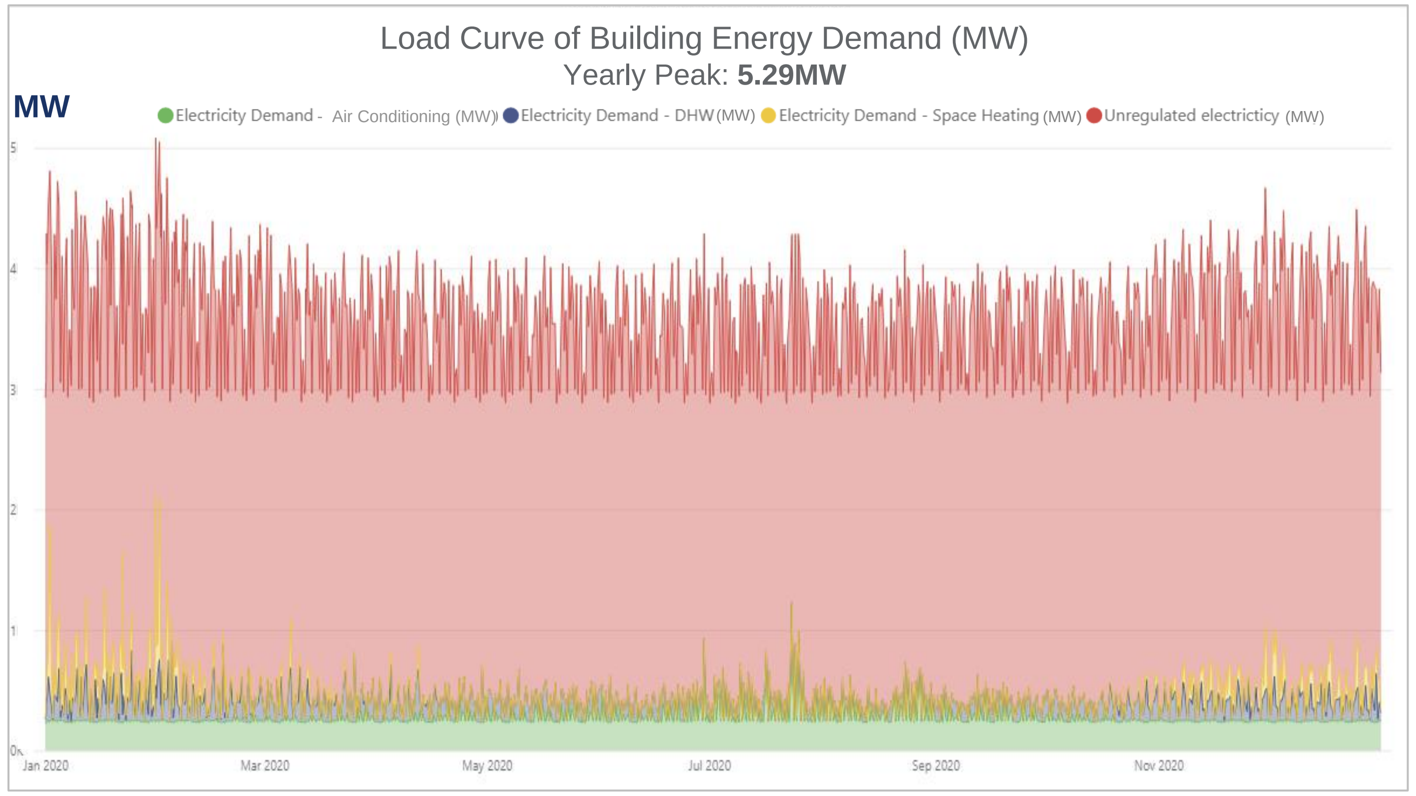
1.3. Energy demand in the buildings



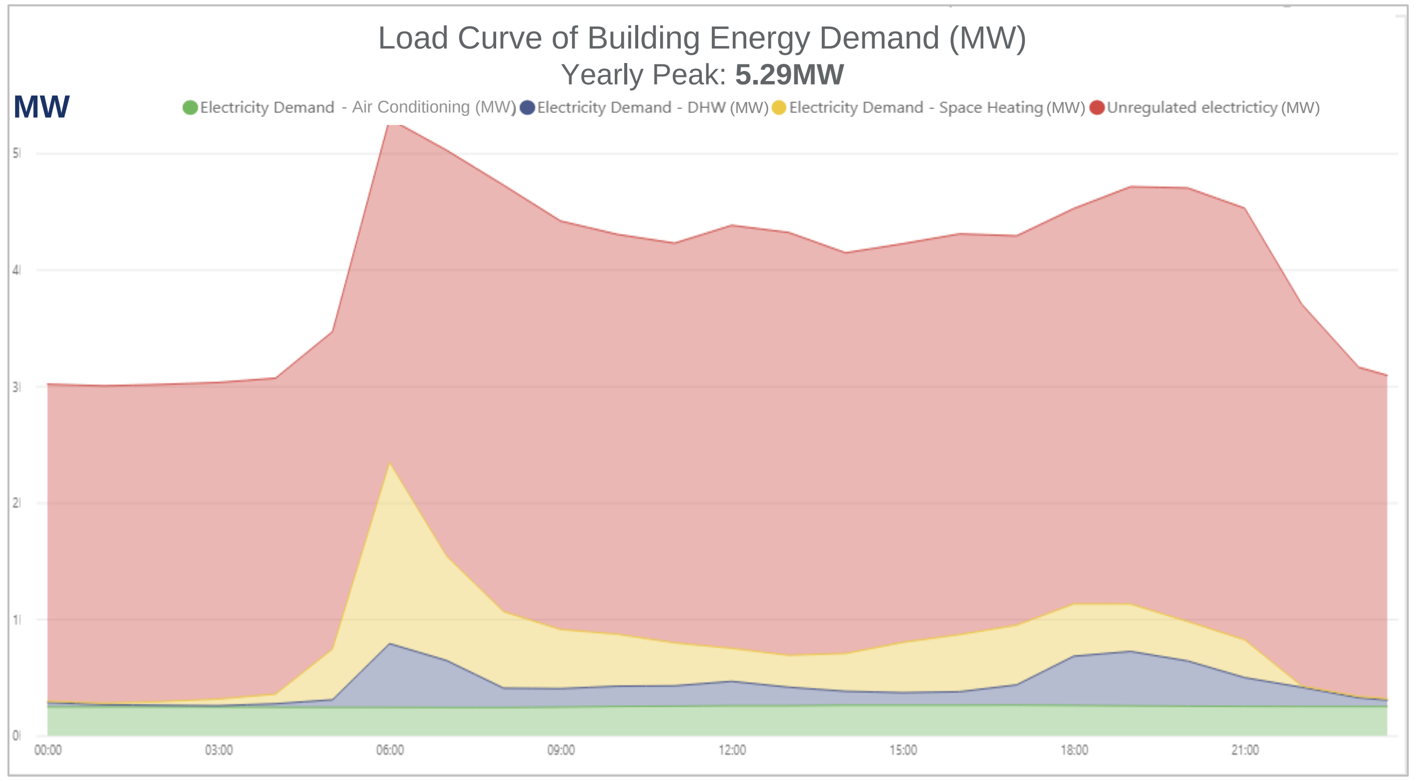
Load Curve: Daily and Yearly analysis

LOAD CURVE OF BUILDING ENERGY DEMAND PER USE TYPES

YEARLY



DAILY



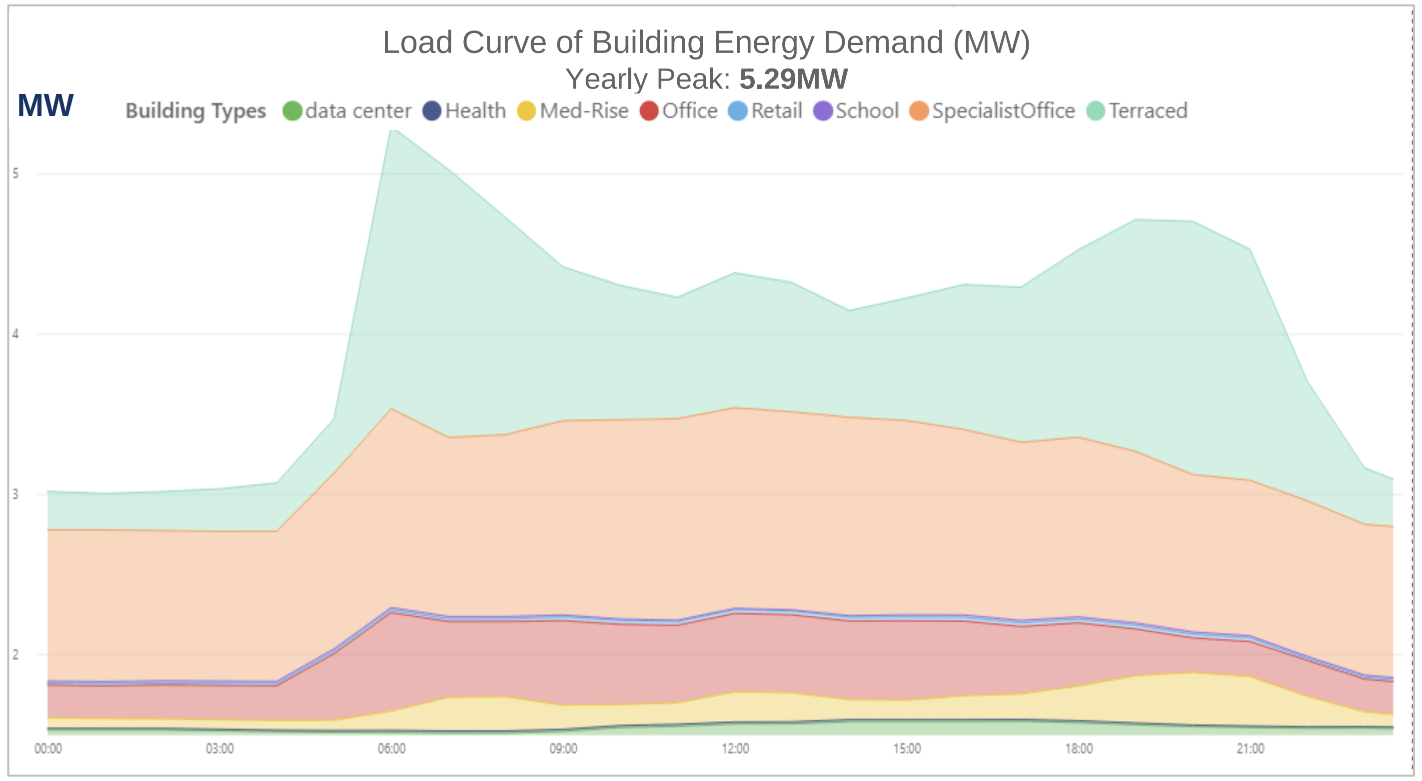
Scenario :

- Decentralised production system – Air/Water heat pumps
- **Presence of a data centre**
- **Heat pump inverters**

Observations:

- Yearly peak = **5.29 MW**
- Overall Building Yearly Demand = **31.22 GWh**

LOAD CURVE OF BUILDING ENERGY DEMAND PER BUILDING TYPE



Comparison

Comparison of yearly peaks for building demand for the different scenarios

			Yearly peak demand *(MW)*	Yearly building demand *(GWh)*	SCOP (Seasonal COP)
S1	Decentralised production		5.29	31.22	3.61
			5.28	31.73	2.44
			3.92	18.82	3.61
			3.95	19.65	2.44
S2	District heating		5.43	36.78	1.01
			4.60	23.66	0.9
S3	Ambient loop		4.59	32.13	5.3
			4.68	32.37	3.2
			3.24	18.62	4.14
			3.46	19.64	2.49

- **Unregulated electricity** is (by far) the most important part of the building energy demand when we analyse the load curve by use.
- The **terraced houses** and the **specialist offices** represent most of the building energy demand when we analyse the load curve by building typology.
- For the scenarios with a **Data Centre**, the demand is highly increased, despite a gain in the efficiency due to the waste heat recovery for the centralised scenarios (2-3), but mainly on the Ambient Loop solution (scenario 3).

Comments and recommendations (1/4)

A very good envelop that minimises the heating need but may cause a high cooling need!

01
Window protection and good glazing to limit the air conditioning need

To minimise the air conditioning need potentially arising from such an efficient envelope, limiting 30% of the solar flux going inside is key to improving the energy efficient consumption of a building, both in terms of heating and cooling.

02
Quality of the envelop (walls, windows & thermal bridge)

The quality of the envelop is crucial for an optimal building energy efficiency : it is therefore essential to respect high requirements and standards. It is also key to choose good external insulation and reduce thermal bridges.
The very high building fabric standards applied in this study allow to reach very low thermal needs and an EUI of around 50 kWh/sqm/y in residential buildings, including unregulated electricity (EUI between 20 to 30kWh/sqm/y for space heating and DHW).

03
Efficient lighting and control

Due to the reduced thermal needs, the share of the unregulated electricity in the building needs is high. Lighting and electric appliances must be chosen with special attention to reach a further level of efficiency.
Lighting needs to be properly set and controlled to avoid too much heating gain. The standard would be 1W/m² for residential and 2W/m² for tertiary.

04
Efficient domestic appliance

Domestic appliances (such as ICT, HiFi, screens, cooking, fridges) also play a key role on long-run energy efficiency, and energy sobriety should be a key criteria for choosing these appliances, allowing long-run energy and cost savings.

05
Ventilation

Ventilation is a key factor in terms of energy efficiency, especially in residential buildings where it is operational 24/7. It can allow for the recovery of up to 90% of the heat.

06
Education

Reasonable consumption of energy should be encouraged by optimising the cost-benefit ratio of “green” behaviors (nudge can be a relevant answer).

07
Monitoring & benchmarking

Close monitoring of energy consumption is essential to quickly detect / correct potential issues and improve performance. Communicating more on this subject, for example by giving a comparison of the energy consumption of residents compared to a local benchmark within the neighbourhood, also makes it more tangible.

Comments and recommendations (2/4)

08

Scenario 2 using a heat network (70/45 °C) seems inefficient in the case of Salt Cross Garden Village

- Scenario 2 appears to be inefficient for this project due to extremely low energy linear density (0.5 MWh/ml, versus the minimum density usually used for profitability which is 3 MWh/ml). This is due to the high fabric quality of the buildings (small thermal needs) and to the large number of individual houses, leading to a long network with a large number of connections, meaning higher thermal losses.
- The thermal losses would be higher than the actual thermal needs of buildings (up to +1MW needs from thermal losses).

09

Scenario 3 (the ambient loop solution) would be a better hybrid solution than the fully centralised one

The low temperature ambient loop is favourable to avoid the significant thermal losses present in a district heating solution. However, they're usually used for smaller systems (50-100 houses), so it may be beneficial to instead consider several smaller loops rather than a village-wide one.

11

Scenario 1 (decentralised) also shows good efficiency. Here, the choice of heat pump technology, including its control is key

The domestic hot water is considered as semi-instantaneous production, which involves hourly storage. The heat pump is often used at partial load with impact on its COP. The use of a compressor with inverter control technology will increase the seasonal COP of the heat pumps. Currently, most of the Air/Water heat pumps (Scenario 1) use inverter controls, when most of the small Water/Water heat pumps (Scenario 3) have fixed speed compressors equivalent to an ON/OFF control system for partial load.

In the case of the Ambient Loop (Scenario 3), it's advised to add DHW storage capacity corresponding to daily storage. The storage addition will on one hand increase the COP of the Water/Water heat pump, but on the other hand allow the production of domestic hot water according to PV production, increasing self-consumption.

10 Heat recovery from the data centre increases the efficiency but adds a large load

- The heat recovery from the data centre increases the efficiency of the system but the choice of installing a data centre should not be made only for this purpose, as it largely increases the overall consumption.
- All the potential heat sources should be considered for waste heat recovery: wastewater heat recovery, local industries or implementing more solar thermal, similar to what is implemented in Scenario 2.b. However, solar thermal was not considered in the ambient loop scenarios as it draws the water at too high of a temperature with too much intermittency, and as the savings would not be able to cover the significant additional costs.

12

Low temperature emitters

Low temperature radiators would be an adapted solution for space heating given the low heating needs and the similar water temperature needs for DHW (60 deg.).

Comments and recommendations (3/4)

13

Scenario 3 could be of interest if the ambient loop is kept at 20°C rather than at 12°C .

Compared to scenario 1 (decentralized HP):

- The seasonal COP (in particular for space heating) is significantly improved in the case of the ambient loop at 20°C (with heat recovery from the data centre). In the case where the ambient loop is heated by the geothermal source only (12°C), the seasonal COP is only slightly improved as the external air temperature would be at the same order of magnitude.
- The total injection of heat from cooling processes in the offices and specialists is lower than the total heat extracted for space heating and domestic hot water.
- The ambient loop appeal would increase if many heat sources would be combined on the loop or if the district had a higher mix of usages (more tertiary, grocery, food storage etc…).

14

The borehole system as a pure source of energy looks to be inferior in this case, however it might be relevant for seasonal storage under the following conditions:

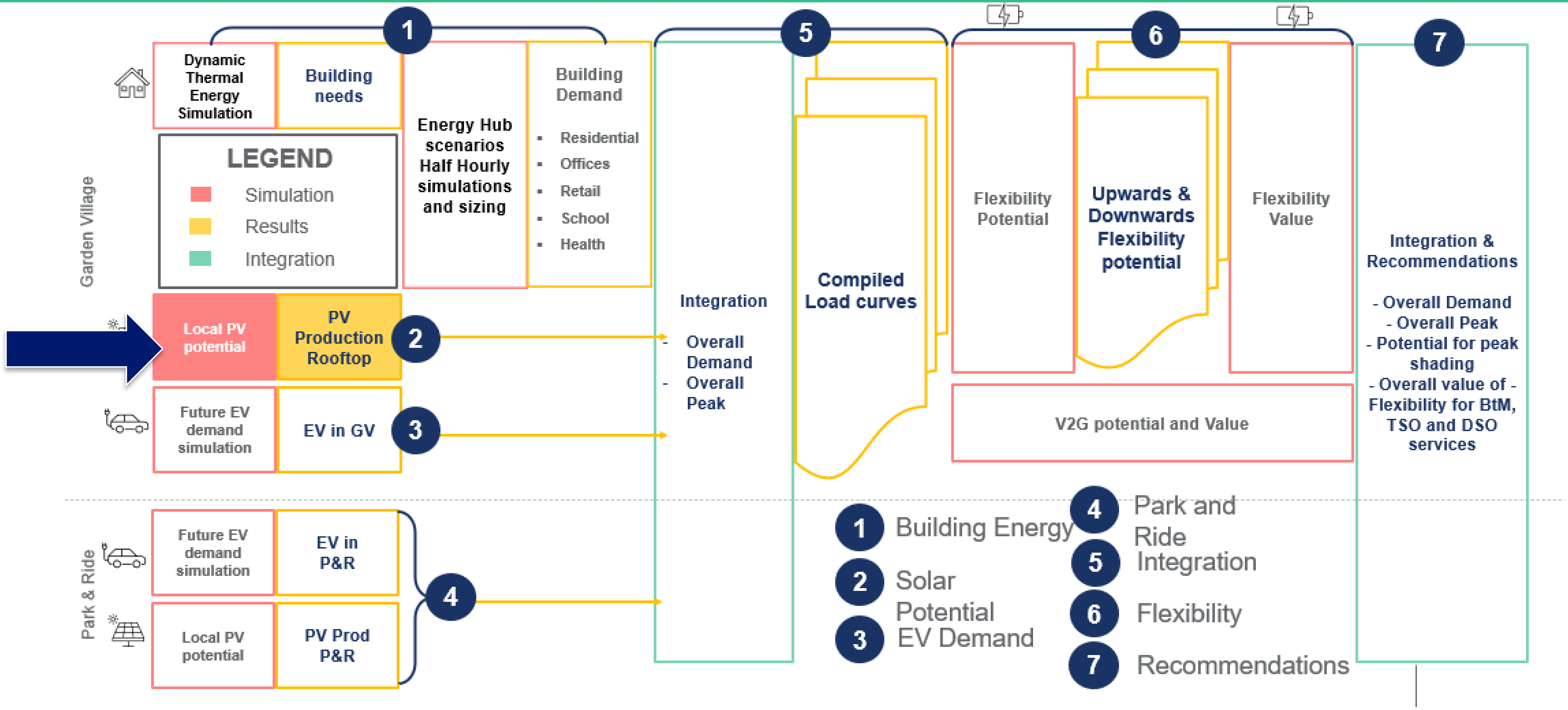
- The data centre is installed and uses free cooling in the winter, and active cooling in the summer (with heat recovery to the ambient loop)
- Heat from wastewater is used as an additional heat source
- Solar thermal is used as an additional heat source
- A higher share of buildings have cooling needs during summer

15

Scenario 1 (decentralized) and 3 (ambient loop) should be compared based upon economic criteria.

- The 2 scenarios are indeed relatively close in terms of their final energy consumption. Therefore, a more detailed study using different types of storages and control strategies, including PV self consumption (as shown with the Flexibility Scenario 3 and 4) could change the overall efficiency and economic balance of both solutions in different ways.
- Storage and the ambient loop are additional investments, air/water and water/water heat pumps represent different investment costs and involve specific operational costs which should be considered in order to make the right decision.

2. On-site PV production



On-Site PV description

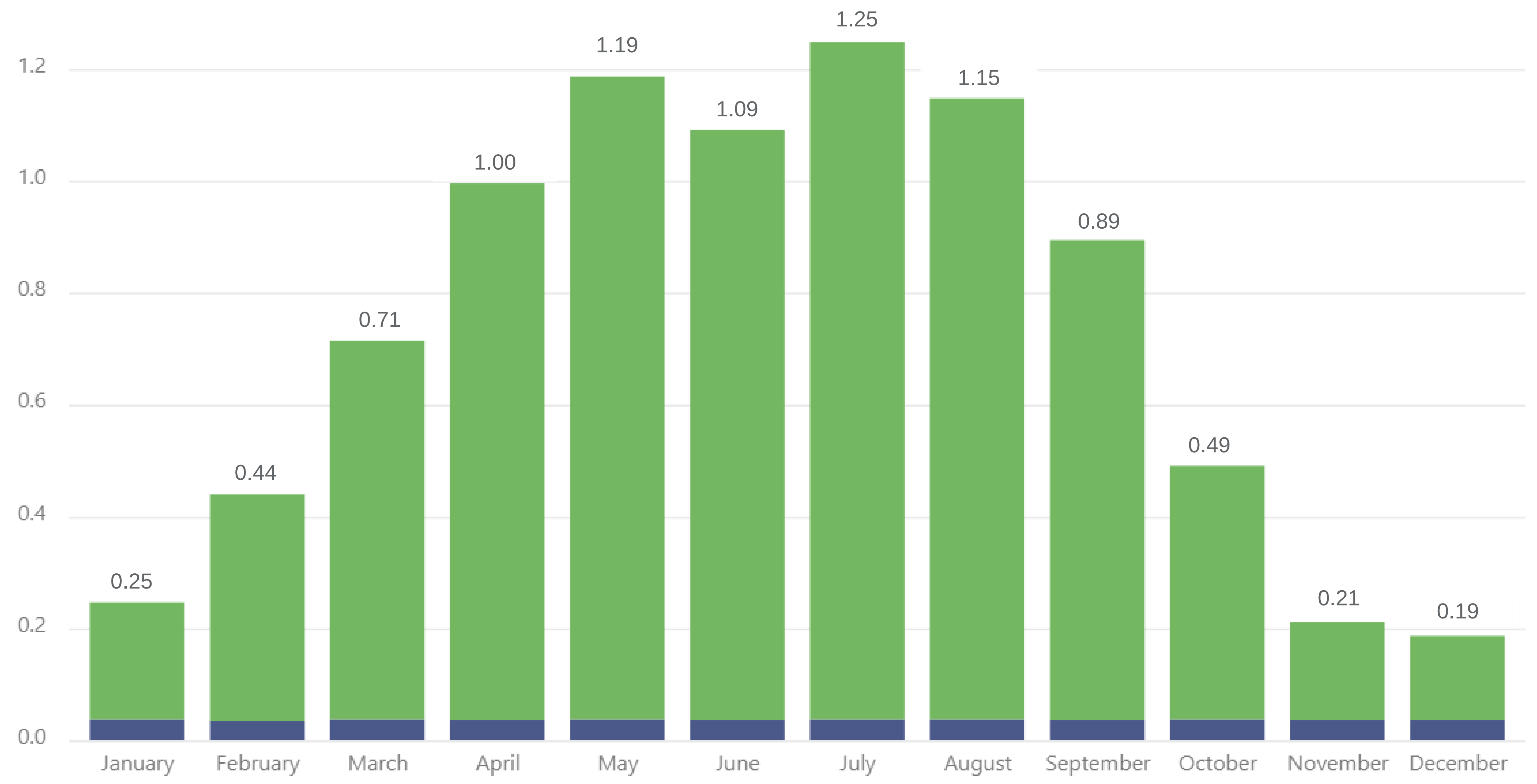
Average Square Metres and Footprint			Quantity	Tilt	APEX	Roof Coverage	Efficiency	Unitary Capacity
	m^2	m^2	Number of buildings	Angle / Degrees (°)	Coefficient (0 to 1)	Percentage	Percentage	kWp
Terraced houses 2 beds	65	36.1	454	40	0.5	70%	16%	2.64
Terraced houses 3 beds	90	50.0	748	40	0.5	70%	16%	3.66
Terraced houses 4 beds	105	58.3	352	40	0.5	70%	16%	4.27
Medium rise buildings	575	127.8	12	0	1	50%	16%	10.22
Health Centre	460	170.4	1	40	0.5	50%	16%	12.47
Offices	4000	1481.5	10	0	1	50%	16%	118.52
Retail	250	92.6	3	0	1	50%	16%	7.41
School 1	3563	1979.4	1	40	0.5	70%	16%	144.93
School 2	5600	3111.1	1	40	0.5	70%	16%	227.79
Specialist Offices	4000	1481.5	10	0	1	50%	16%	118.52
Park & Ride Solar Canopy								500

Assumptions taken regarding PV:

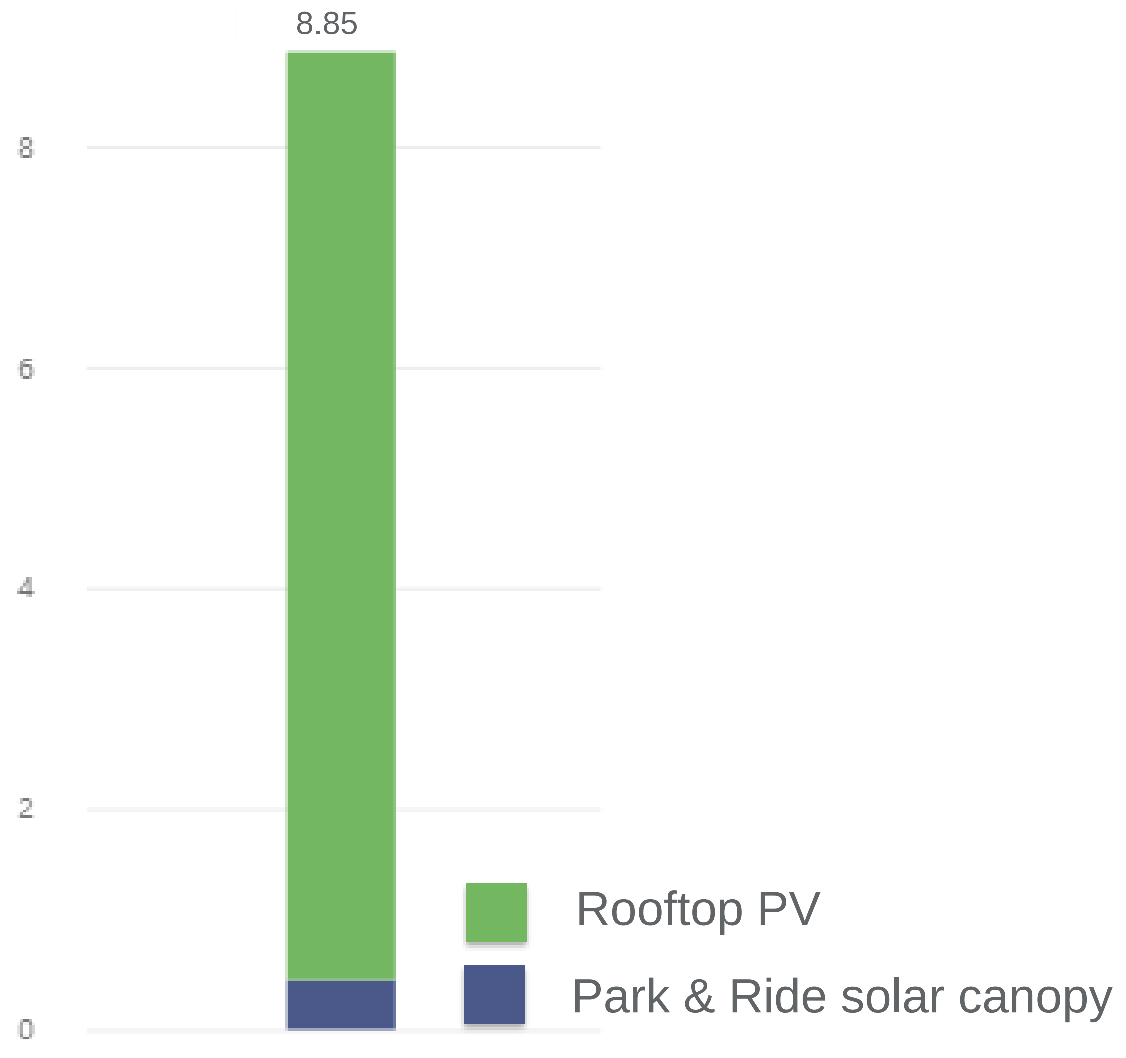
- Number of buildings is in coherence with the AAP.
- Half of the retail buildings have tilted roofs; the other half have flat roofs.
- A 16% PV module efficiency corresponds to moderate efficiency, and consequently, to a moderate and reasonable assumption.
- PV orientation have been optimised when relevant: default North/North-East/North-West orientations have been replaced by South/South-West/South-East orientations.

Local PV production (3/3)

Aggregated monthly PV Production for Salt Cross Garden Village (GWh)



Aggregated yearly PV Production for Salt Cross Garden Village (GWh)



Comments

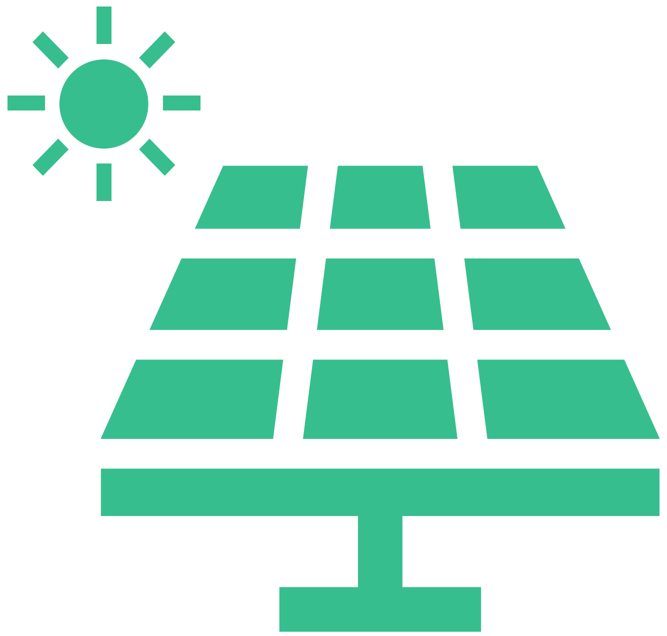
S3	44%
S1	44%
S3	42%
S1	42%
S2	35%
S1	27%
S1	27%
S3	26%
S3	26%
S2	23%

01 PV Production is an important source of local energy generation for the Garden Village

- Based on assumptions taken, the total annual PV potential (rooftop + solar canopy) is 8.85 GWh, with an average of 23 MWh per day (40-50MWh/day in summer, 5-10MWh/day in winter).
- This represents between 23% and 44% of the overall energy demand (buildings + EV + P&R) – See table on the left.
- The self consumption rate is lower than the results of the Elementa Energy Study referenced in the AAP due to the wider scope of energy demand including unregulated electricity, AC and EV (see slide 104), and the assumptions of PV covering considering the types of roofs (see slide 67).

02 Park & Ride solar canopy is slightly increasing the self consumption.

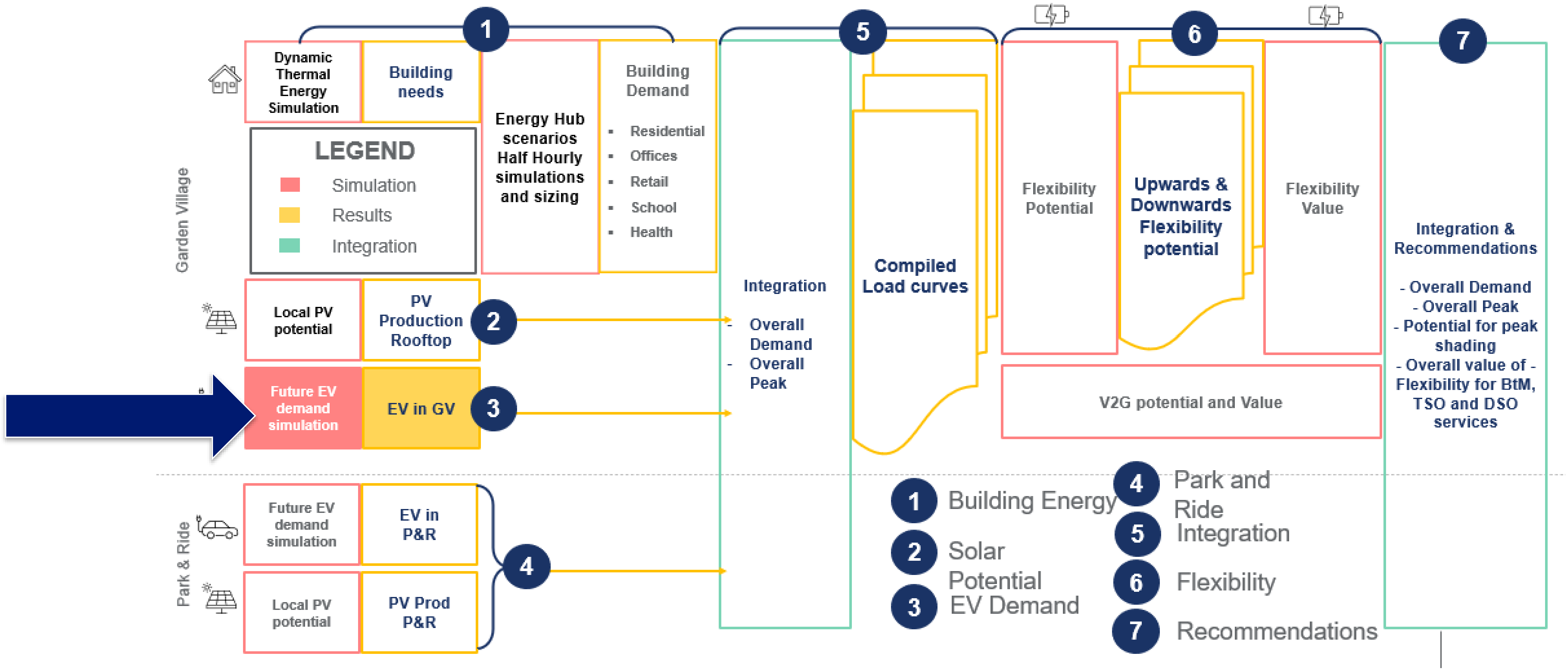
The solar canopy of the Park & Ride represents only 440 MWh (5%) of the total yearly on-site production but is underutilised by the EV charging needs of the park & ride (see section 4.). There is therefore room to increase slightly the self consumption in the Garden Village by using the solar canopy.



03 More mixed used in the Garden Village would help to self-consume more PV by design.

- The Garden Village is mixed-use with a combination of residential buildings and office buildings but the addition of some uses with high demand during the day (retails, services etc.) would ensure a higher PV self-consumption. As we can see on section 5., in summer, the PV generation potential greatly exceeds the building and EV energy demand.
- Solutions for storage and smart charging would help manage the demand and increase self-consumption, as shown in section 6..

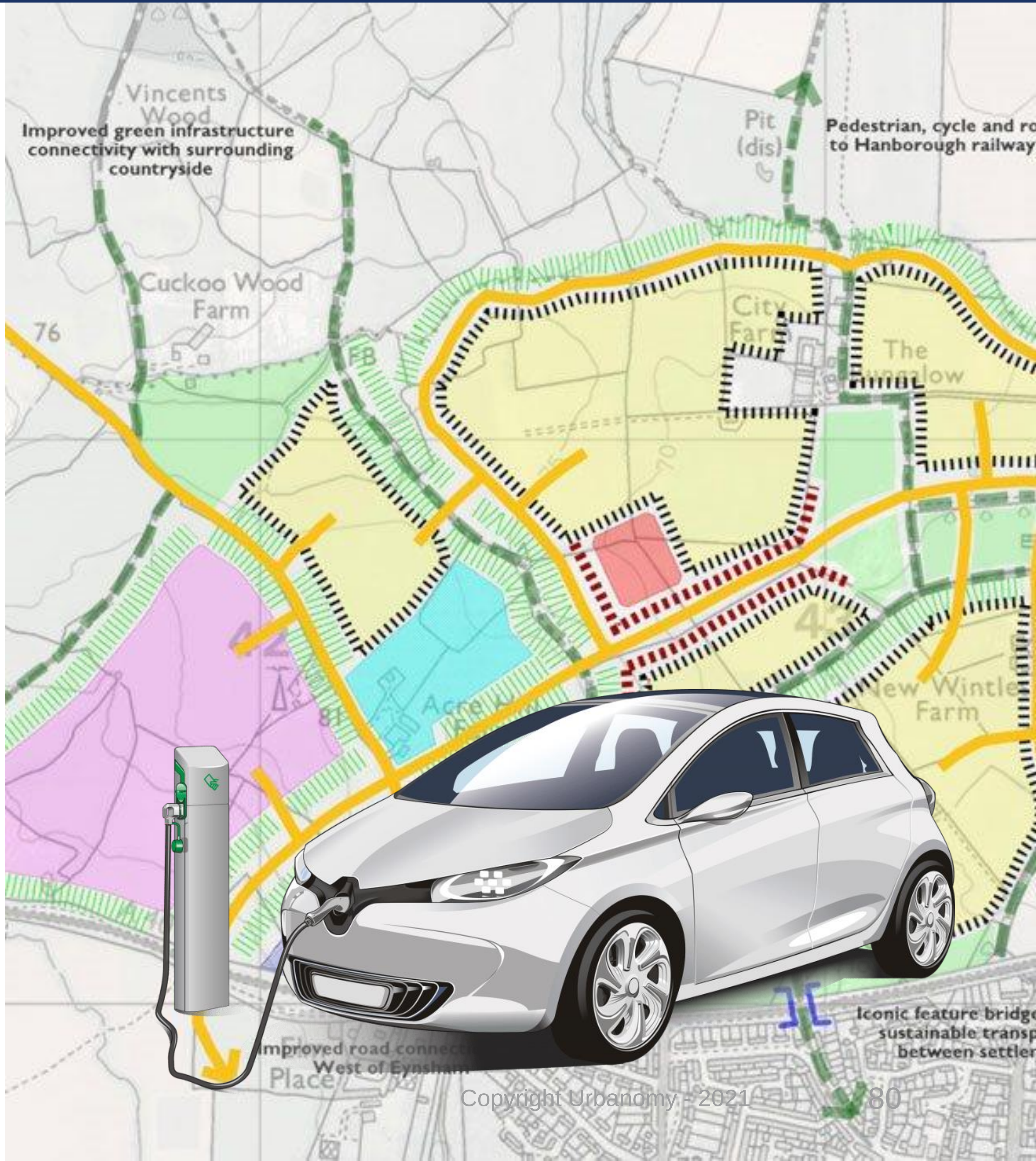
3. Electric mobility demand (Garden Village)



Introduction

What will be the energy demand for Electric Vehicles in Salt Cross Garden Village?

Electric Vehicles (EVs) charging in the Garden Village will be a significant contributor to the site's energy demand. To assist in energy planning for the Garden Village, we used the predicted traffic model for the village in 2031 and its knowledge of EVs and the EV market to model what the daily energy demand profile will be for charging EVs at the site.



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Number of charge points

The number of parking spaces and charge points are obtained following guidelines from the Area Action Plan (pre-submission draft) by the West Oxfordshire District Council (p.144):

The absolute maximum car parking provision shall be 1 space per 60 m² of employment space with residential provision as below:

1 bed units – 0.75 non-allocated per property

2 & 3 bed units – 1 off-street bay per property

4+ bed units – 1 off-street bay per property plus the equivalent of 1 non-allocated bay per property

EV charging points must be provided at the following locations within the Garden Village:

– All residential properties with a parking space
– 50% of non-allocated parking spaces
– 25% of non-residential development parking spaces

Number of parking spaces			
Allocated	Unallocated	Visitors	Employment
1820	683	440	992

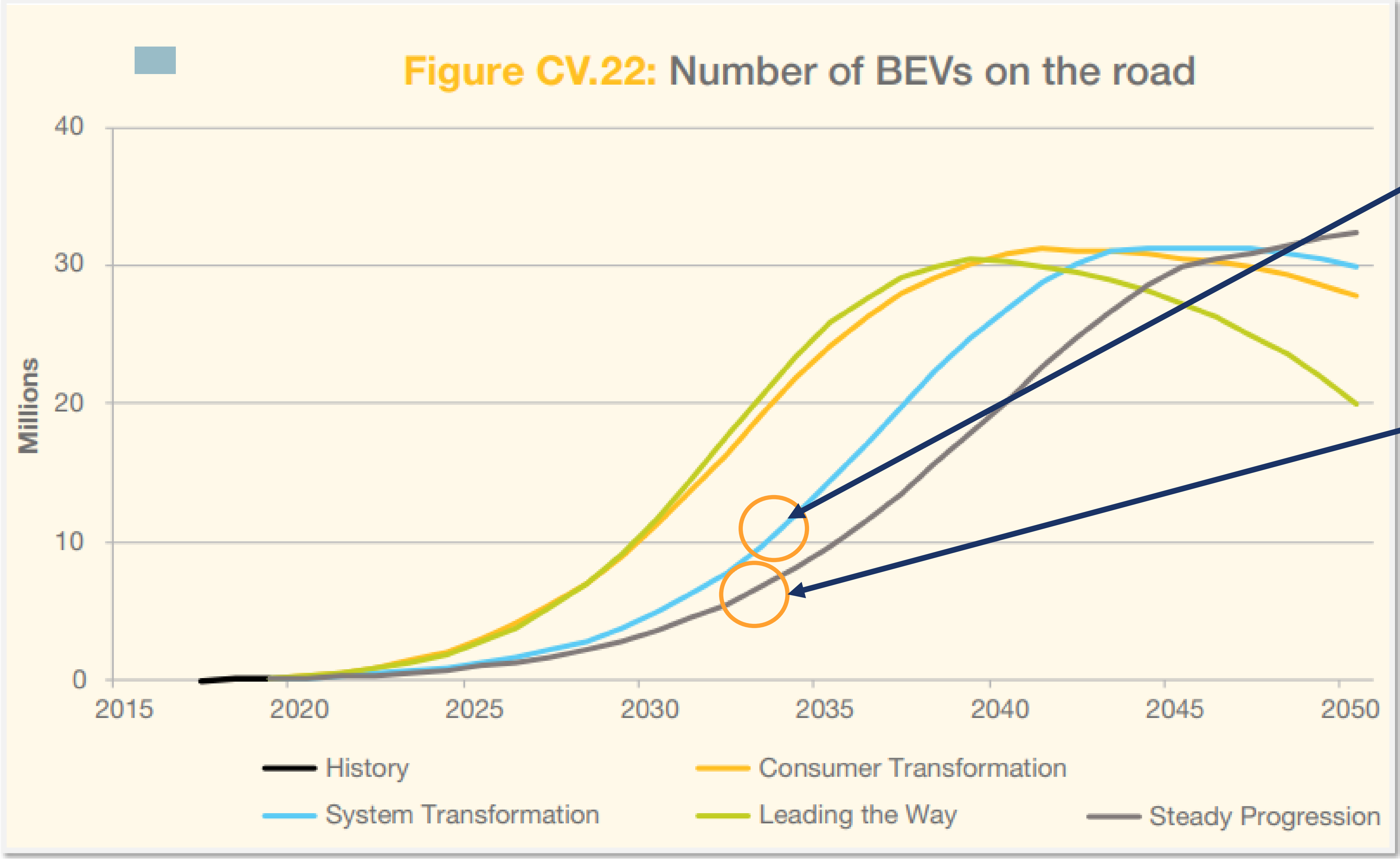
Total number of parking spaces: 3932

Number of charge points		
Residential	Unallocated	Employment
1820	561	248

Total number of charge points: 2629

EV market penetration in 2030

The Future Energy Scenarios (2020 release) from the National Grid forecasts 4 scenarios regarding the uptake of battery electric vehicles (BEVs) in the UK by 2050.



2 scenarios are kept for this study:

1. High uptake = 11.4 million EVs in circulation by 2033.
→ 38% of EVs

2. Steady Progression = 4.2 million EVs in circulation in 2033.
→ 14% of EVs

Note: this forecast was released before the UK government announcement to ban sales of ICE vehicles by 2030. Therefore the "High uptake" scenario would seem the most reasonable for 2033.

Deriving an EV load curve: EV occupation behaviour

The assumed behaviour for a vehicle is as follows:

Arrives at GV → Parks & Plugs-in immediately → Charges → OR → Finishes Charging → Departs GV

According to the traffic model in the 2031 Forecast Year Modelling Report, there are two principal groups coming/going to the Garden Village:

Morning Peak
Arrivals mostly include employees coming from outside the GV to work

Evening Peak
Arrivals mostly include residents who are returning to the GV after working elsewhere or spending the day out

This approach makes the following assumptions:

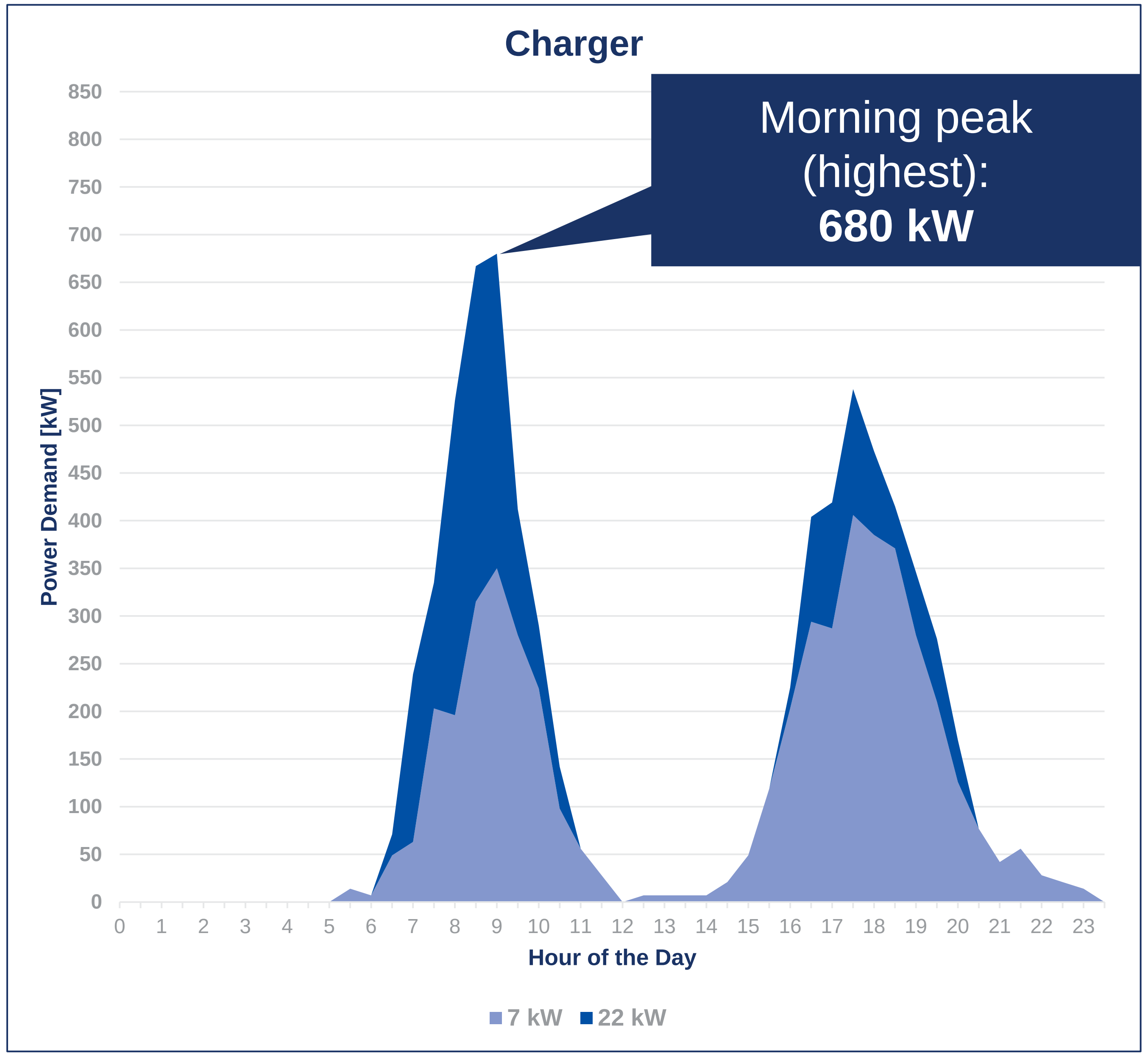
- The number of very short stays and drop-offs, for example for schools (arrive and depart without plugging-in) are negligible.
- Vehicles park immediately once arriving at the GV.

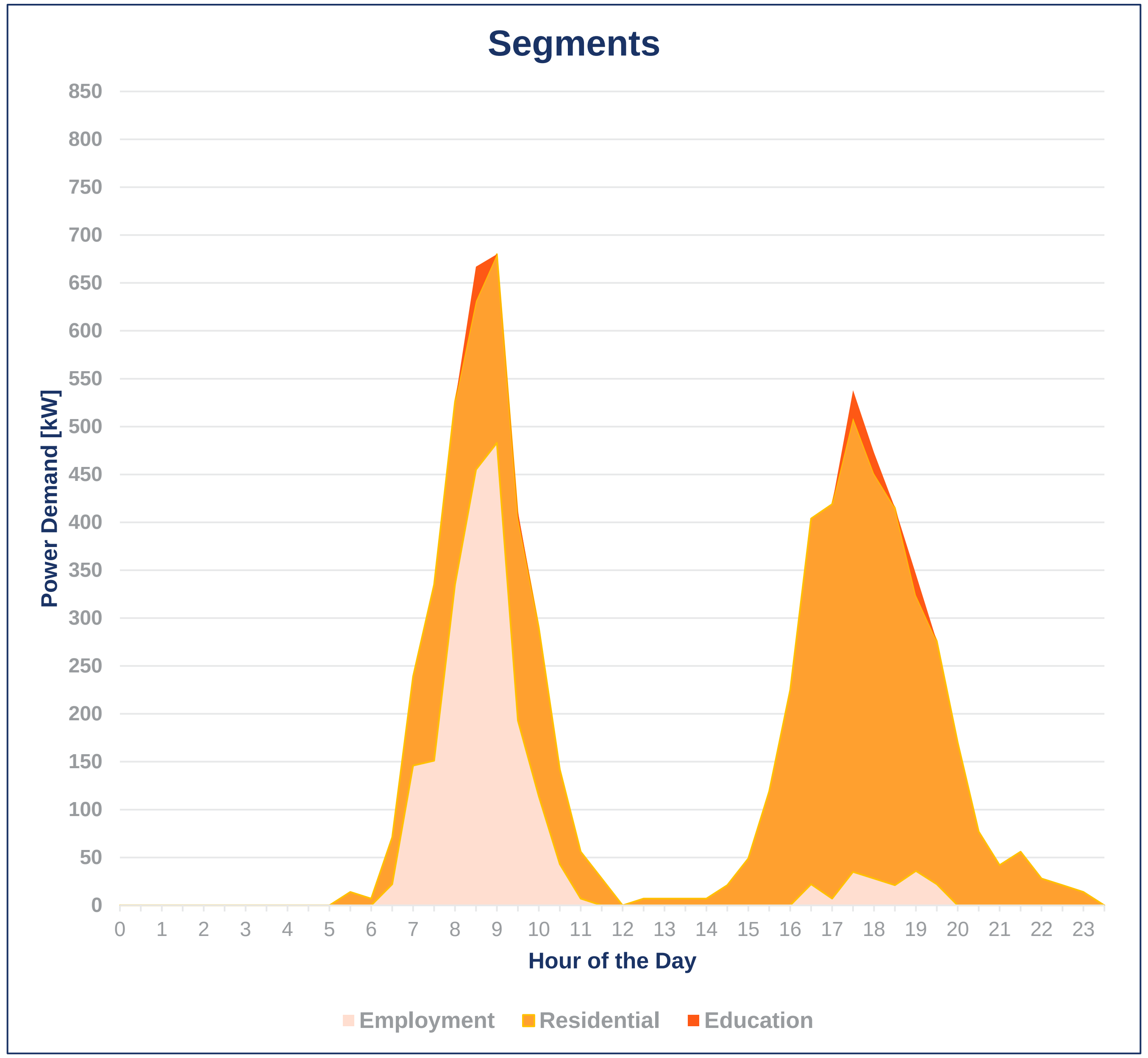
Modelling results: 4 different cases

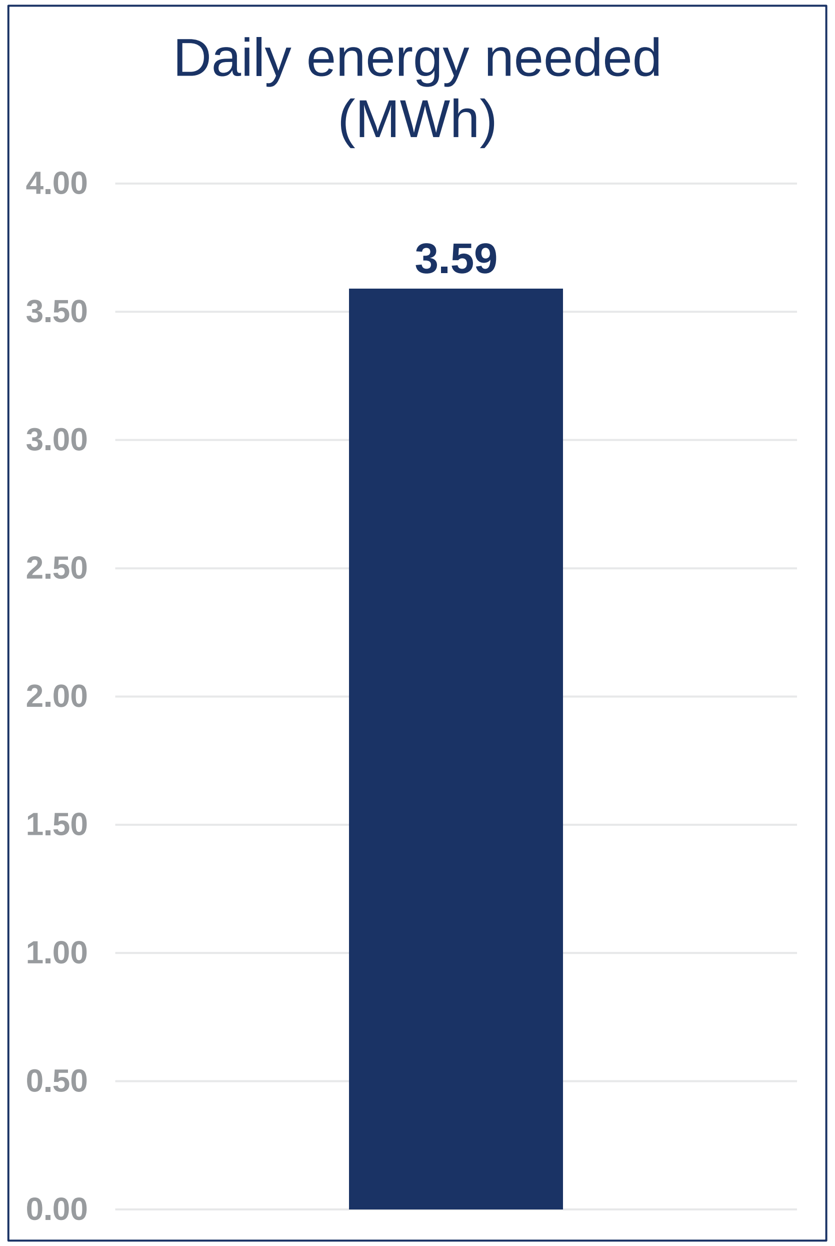
EV Scenario	EV penetration	Rapid charging (50KW)	Residential Chargers (%)			Employment Chargers (%)			Education Chargers (%)		
			7kW	22kW	50kW	7kW	22kW	50kW	7kW	22kW	50kW
Case 1	38%	-	80 %	20 %	-	40 %	60 %	-	40 %	60 %	-
Case 2	14%	-	80 %	20 %	-	40 %	60 %	-	40 %	60 %	-
Case 3	38%	✓	75 %	15 %	10 %	35 %	55 %	10 %	35 %	55 %	10 %
Case 4	14%	✓	75 %	15 %	10 %	35 %	55 %	10 %	35 %	55 %	10 %

Modelling results: case 1

CASE 1
- 38% EV Penetration
- Residential Chargers: 80% 7kW, 20% 22 kW
- Employment Chargers: 40% 7 kW, 60% 22 kW
- Education Chargers: 40% 7 kW, 60% 22 kW







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Comments and recommendations

01

The EV demand represents a relatively small percentage of the overall demand but can increase the peak demand significantly.

- The overall demand is increased between 4% and 8% by the electrification of transport in the village, in the highest penetration scenario (38% of EV).
- The peak demand is increased by the EV morning peak between 2% and 17%, without any smart charging management implemented.

02

The correlation of plugging time for the science park and the schools can result in a high morning peak

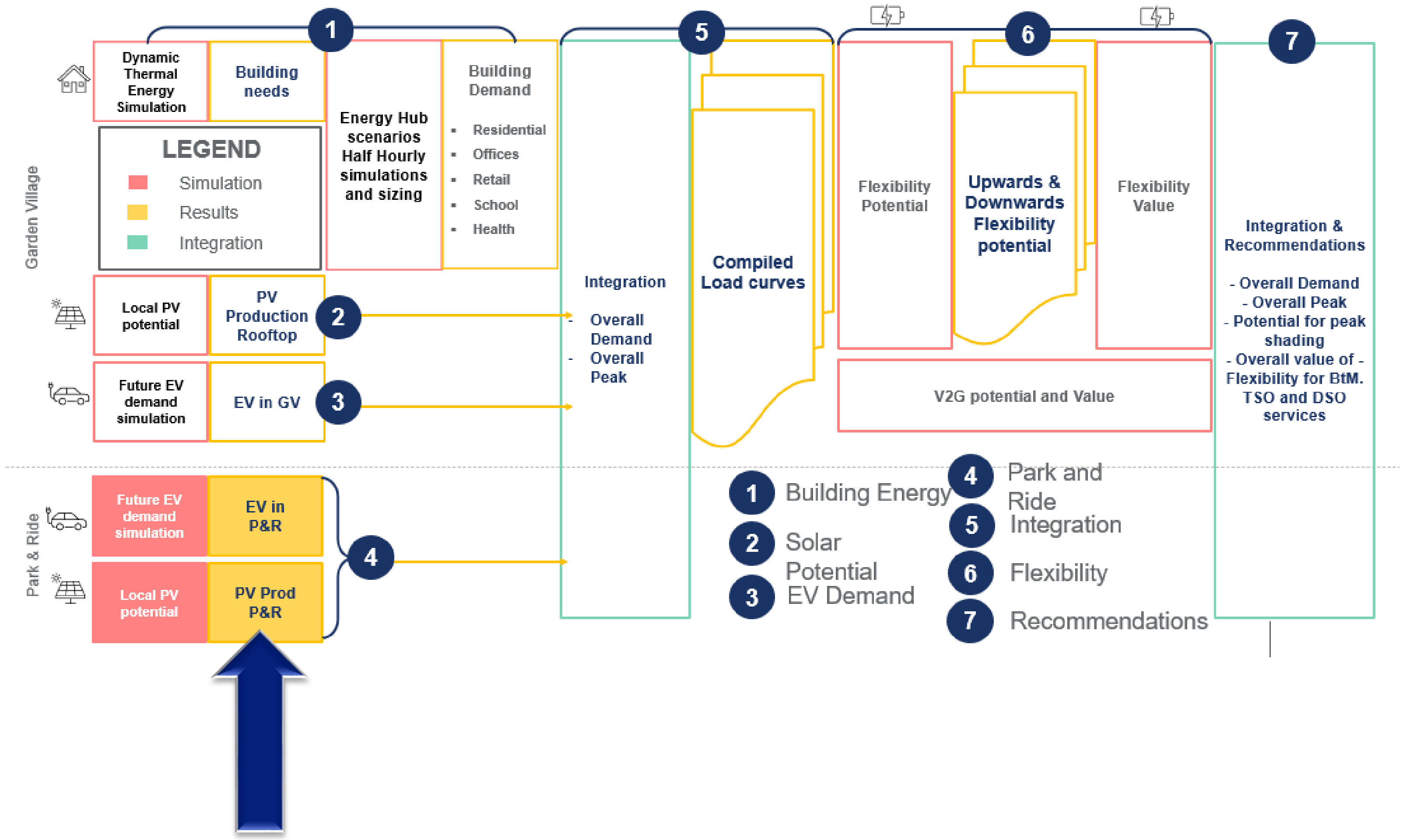
The morning peak (roughly 7AM-10AM) is quite high, mainly due to common arrival time for employment in the science park and for education at the schools (for teaching staff mainly as plug-in during drop-offs are negligible). The morning peak can be smoothed out by several measures for the employment and education segments, such as a system of incentives (e.g., adapted parking solutions and fees, flexible working hours) and smart charging (see Section 6.). This would reduce the impact on the grid.

03

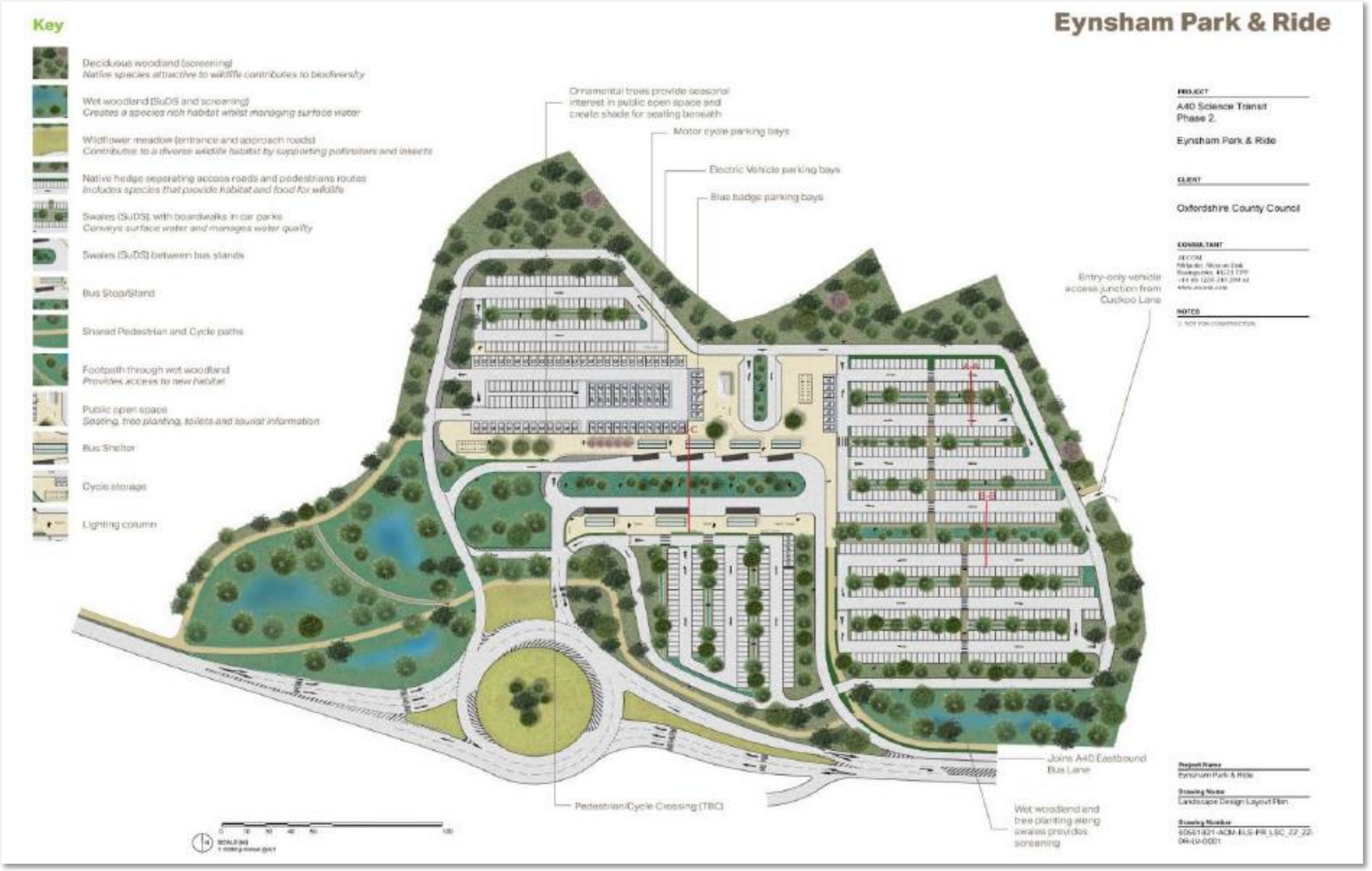
The evening peak can be managed with smart management and night charging for the residential uses.

- The evening peak (roughly 4PM 7:30PM) remains important due to similar arrival hours in the residential parts of the Garden Village. A smart charging system could be implemented and encouraged for charging during the night to minimize the EV charging impact on the grid while allowing residents savings.
- The time window of this peak corresponds to high energy prices but also the DSO services availability window, leading to opportunities to provide flexibility, if the batteries have a SOC of above 30% and are aggregated.

4. Electric mobility demand (Park & Ride)



Park & Ride – Reminder of EAP results (2019) and adaptation to EV scenarios



Proposed design – AECOM - 2019

These results have been updated from the EAP study conducted in 2019 to reflect the scenarios defined in the above EV study for the charge points in the garden village. The park and ride demand and generation have been integrated in the overall demand of the Garden Village.

Park & Ride – Assumptions and cases

Park & Ride

EV Charge Points	Solar Canopy	Local Load
45 Charge Points	Covers the parking spaces, up to 1,000 spaces	Assumed to follow a restaurant-like load curve, scaled to a third the size, time-shifted to match early arrival of drivers

From the EAP (2019), the assumptions chosen for this study are the PV assumptions from the Scenario 2:

Scenario description

45 Charge points (for types see scenarios below)	500 kWp	Café as usual

PV assumptions

Regarding EV, 4 cases are considered, based on the EV market penetration and on the integration or not of rapid charging: same scenarios than mentioned before (slide 41), but keeping only the line focused on employment, as the Park & Ride space will mainly serve the employment area

	No Rapid charging	**Rapid charging (50KW)**
38% EV penetration	**CASE 1** • 38% EV Penetration • Employment Chargers: 40% 7 kW, 60% 22 kW	**CASE 3** • 38% EV Penetration • Employment Chargers: 35% 7 kW, 55% 22 kW, 10% 50 kW
14% EV penetration	**CASE 2** • 14% EV Penetration • Employment Chargers: 40% 7 kW, 60% 22 kW	**CASE 4** • 14% EV Penetration • Employment Chargers: 35% 7 kW, 55% 22 kW, 10% 50 kW

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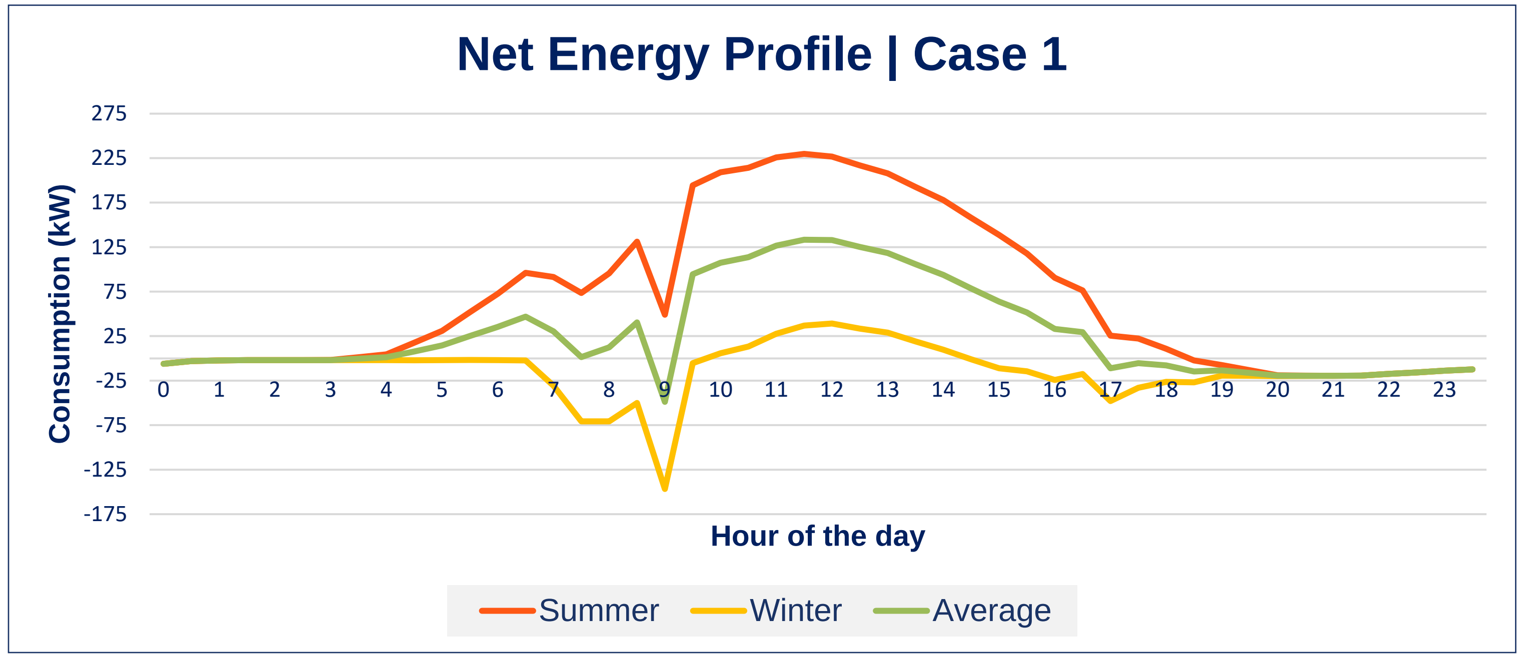
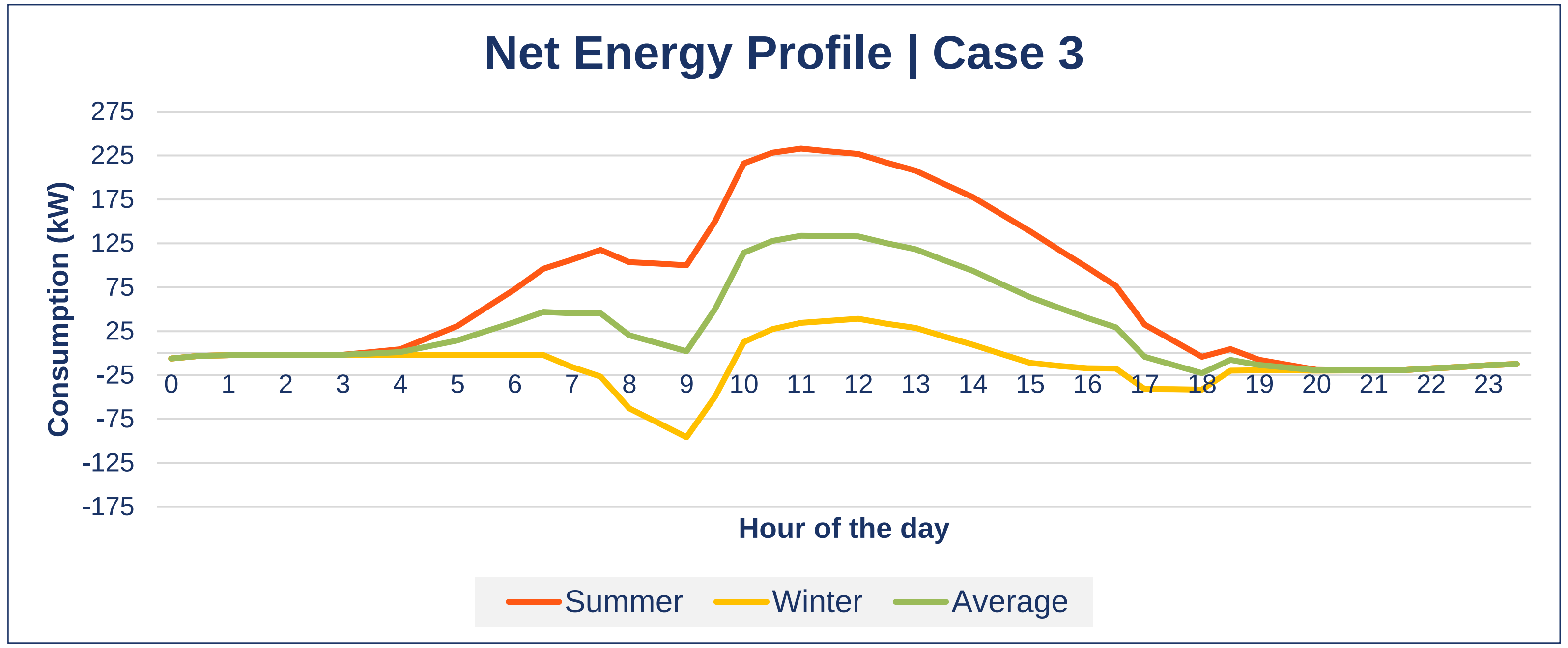
Comparison of the Net Energy Profiles of the 4 cases for the Park & Ride

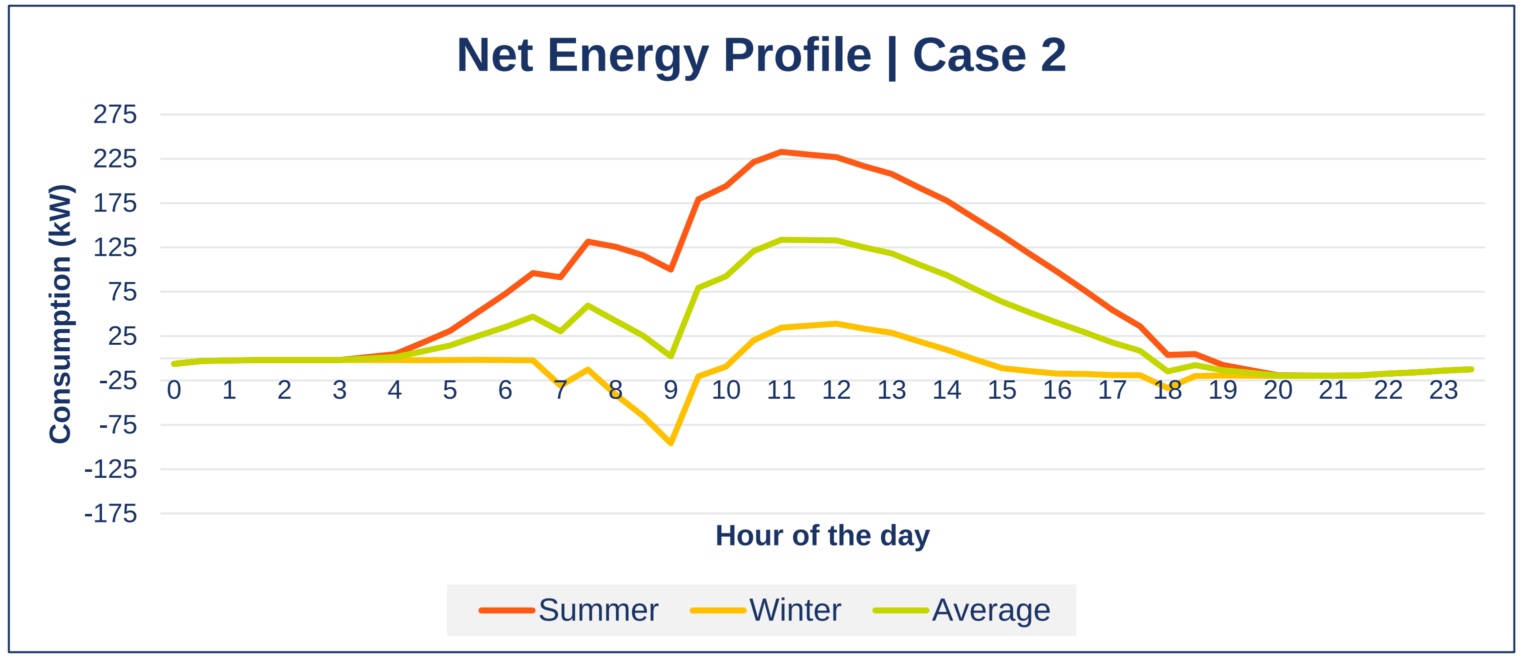
No Rapid charging | Rapid charging (50KW)

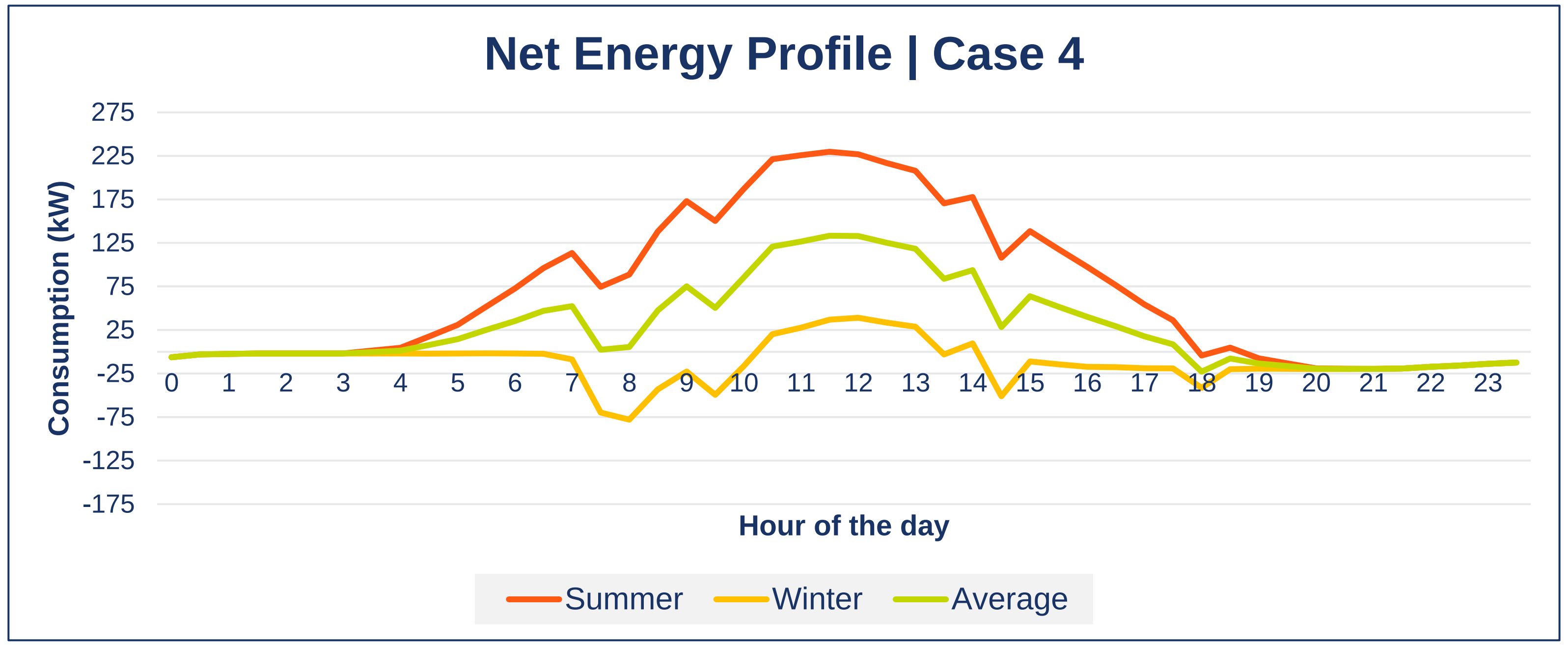
38% EV penetration





14% EV penetration





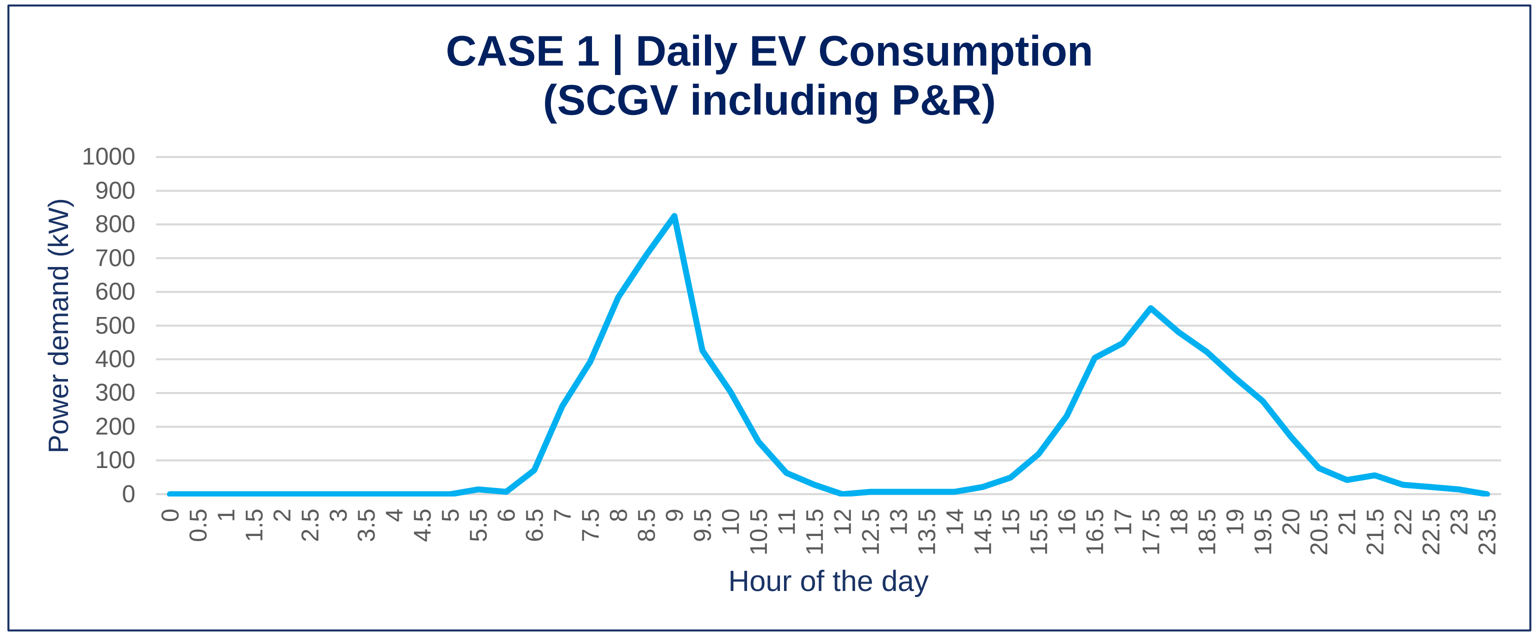
- Low EV market penetration = lower EV charging peak around - 95 kW in winter (vs. up to-145 kW in winter for high market penetration)
- In any configuration, local solar production will not be sufficient to allow full autonomy of the P&R throughout the year : connection to the electricity grid is required both to sell the surplus and to alleviate the shortage related to peak hours. Depending on costs, it can also be interesting to install local storage batteries to increase the self-consumption rate

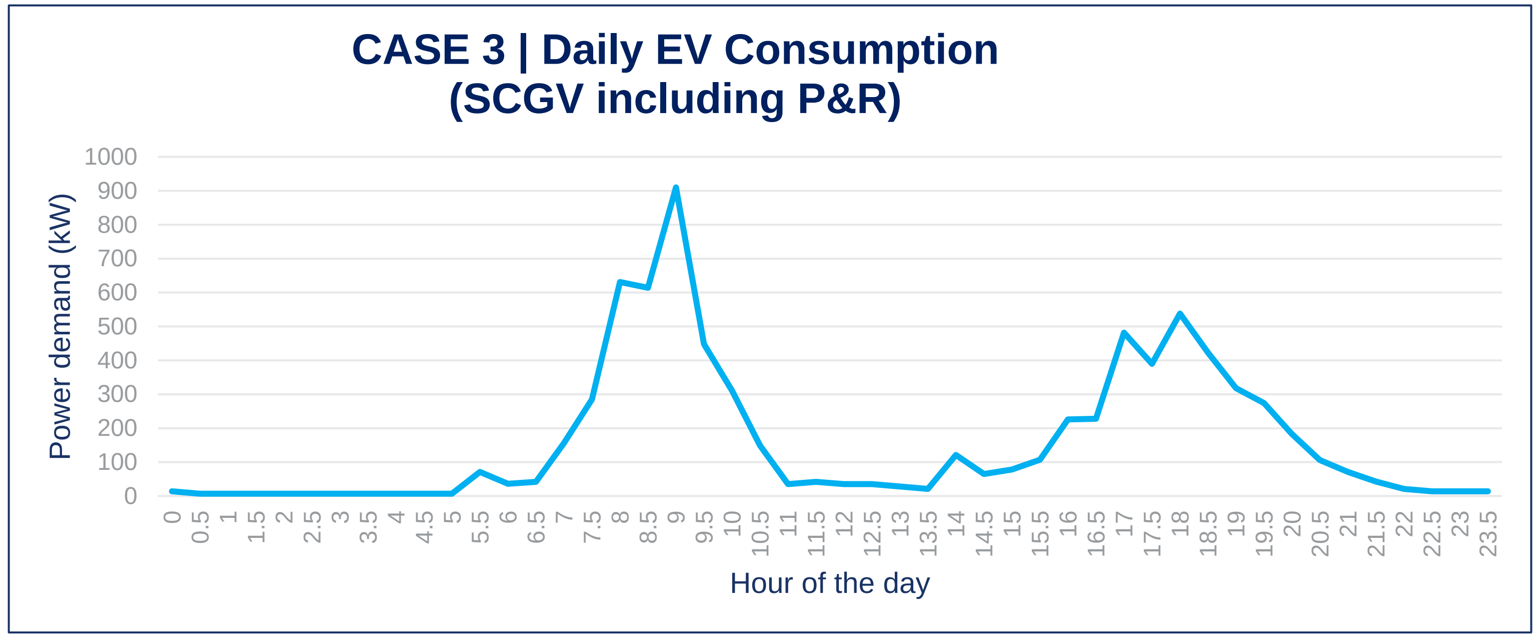
Electric Mobility Total (EV + P&R)

No Rapid charging

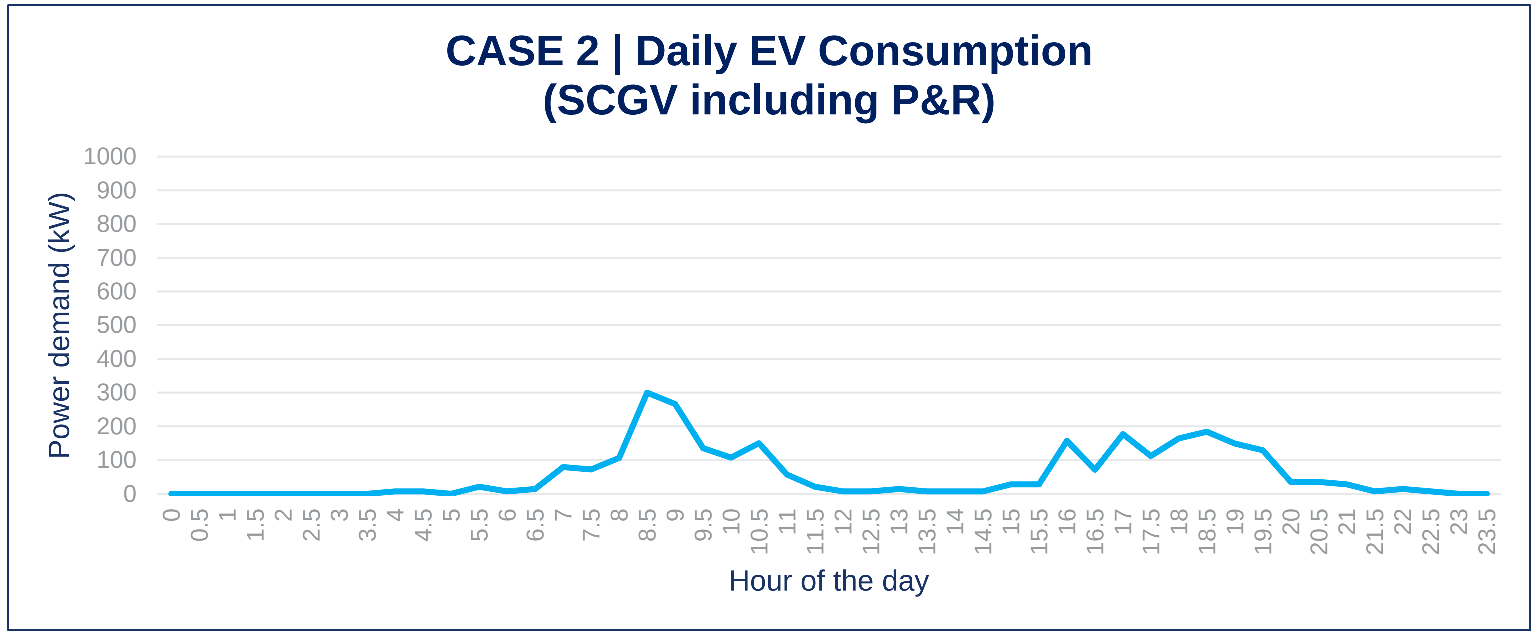
Rapid charging (50KW)

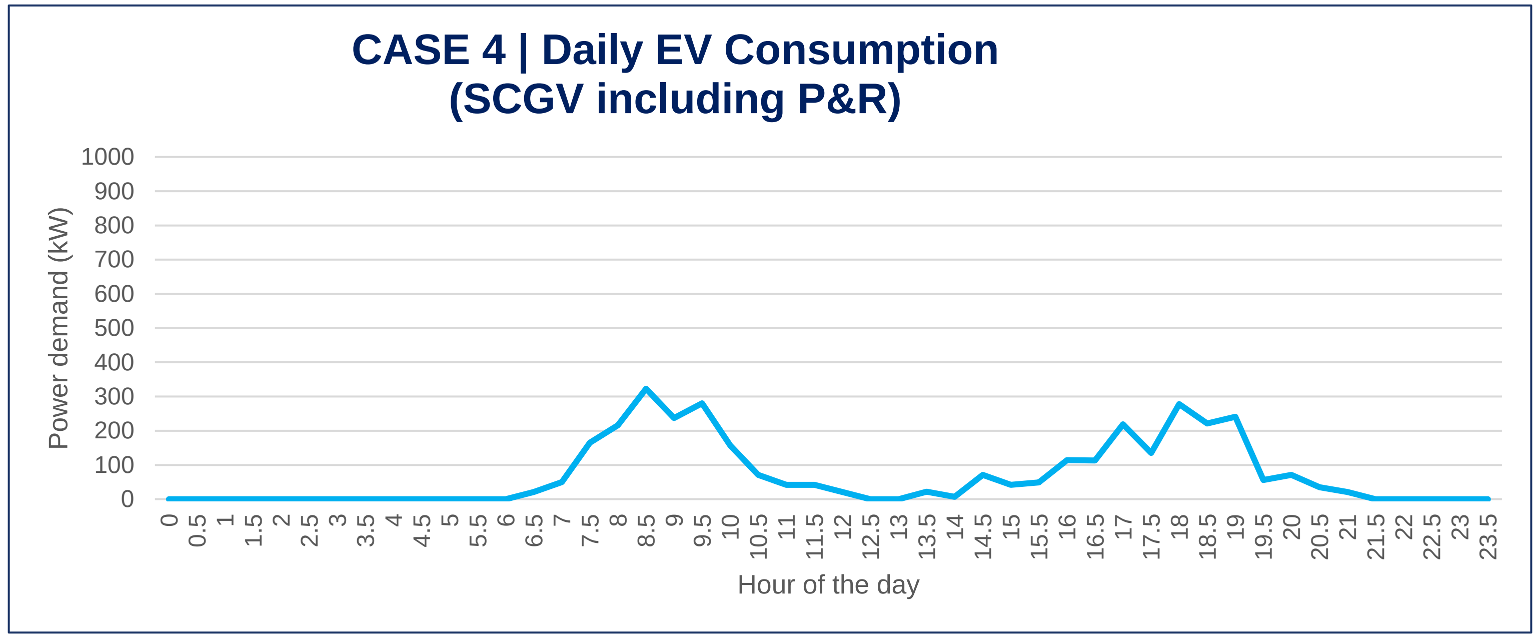
38%
EV penetration





14%
EV penetration





- Lower EV market penetration = Lower EV consumption: peaks below 400 kW for both low EV penetration use cases, vs. up to more than 800 kW and 900 kW without and with rapid charging.
- In both cases, the peak is higher when rapid charging (50kW) units are included.

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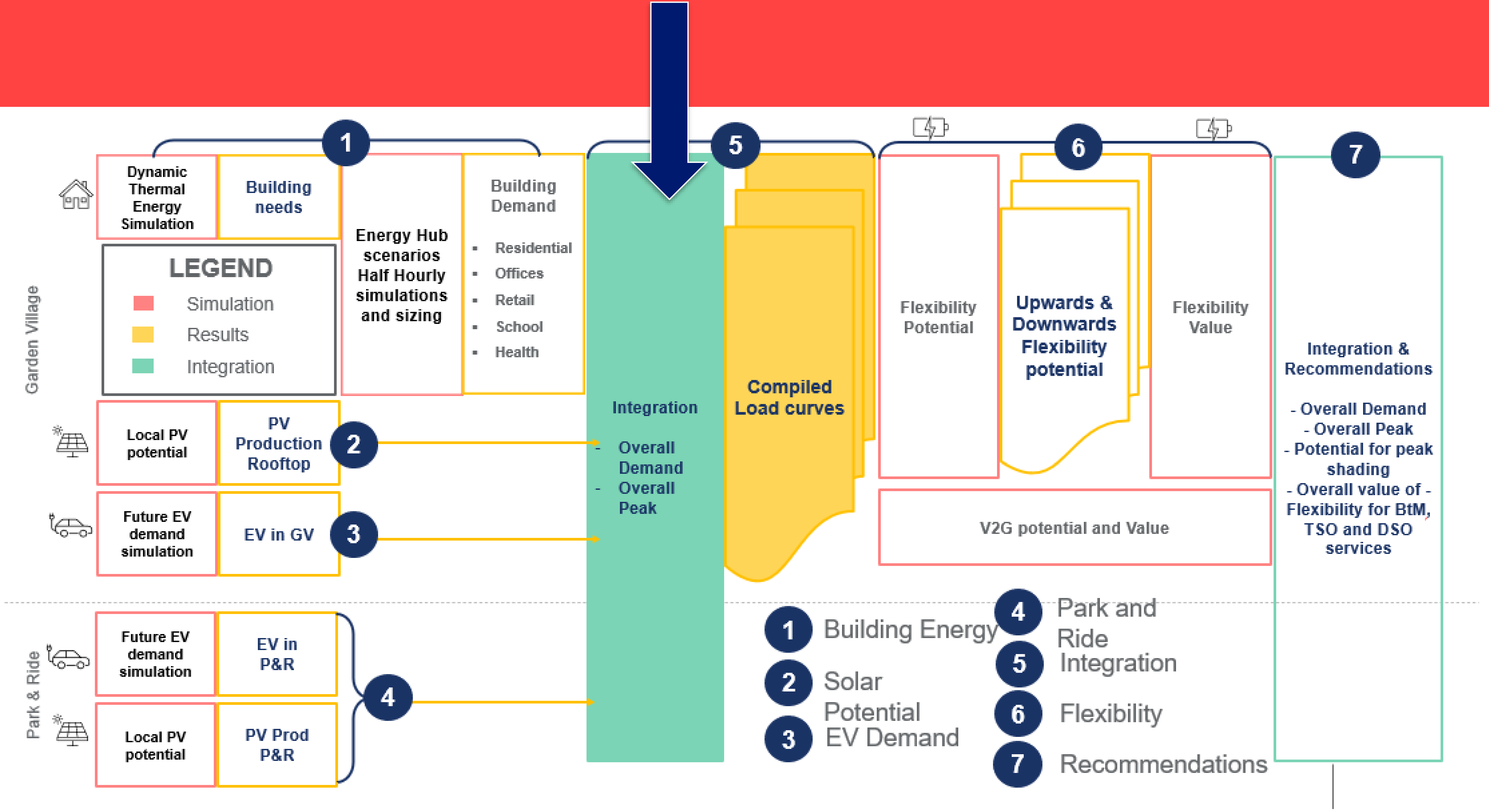
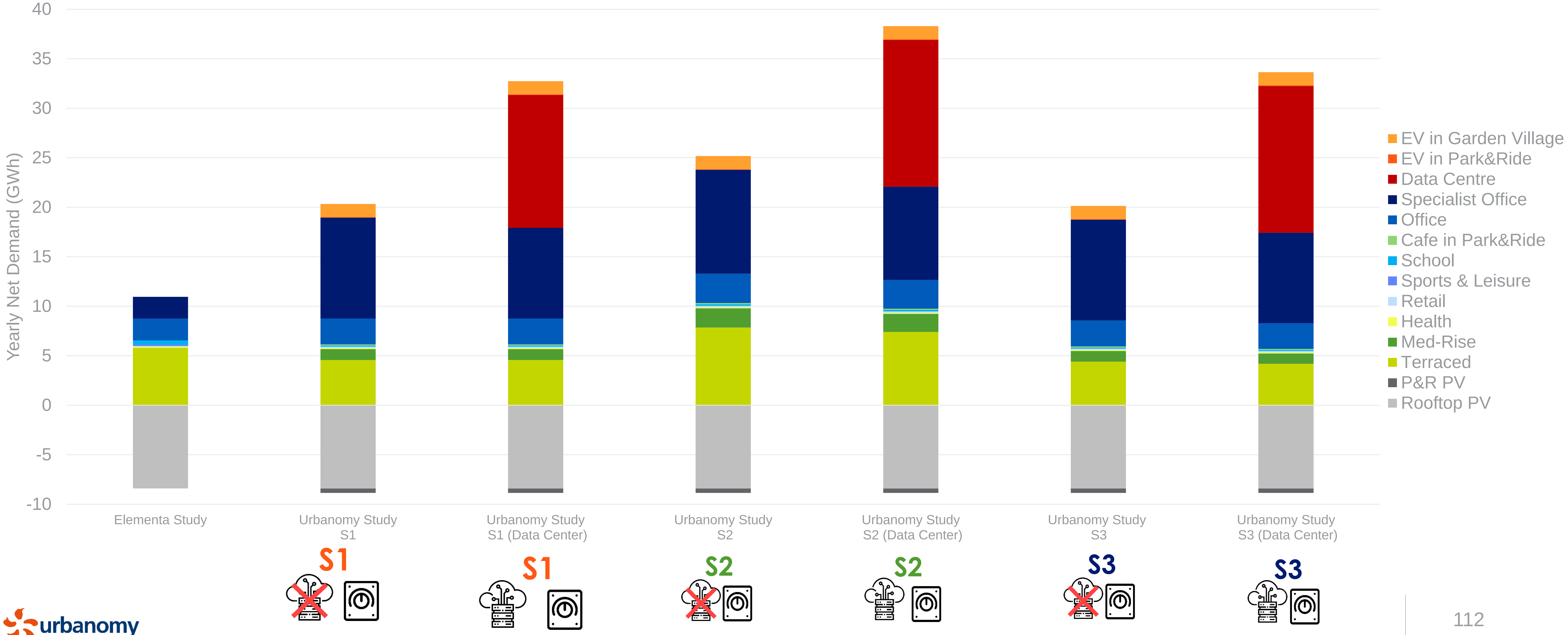
5. Integrated load curve

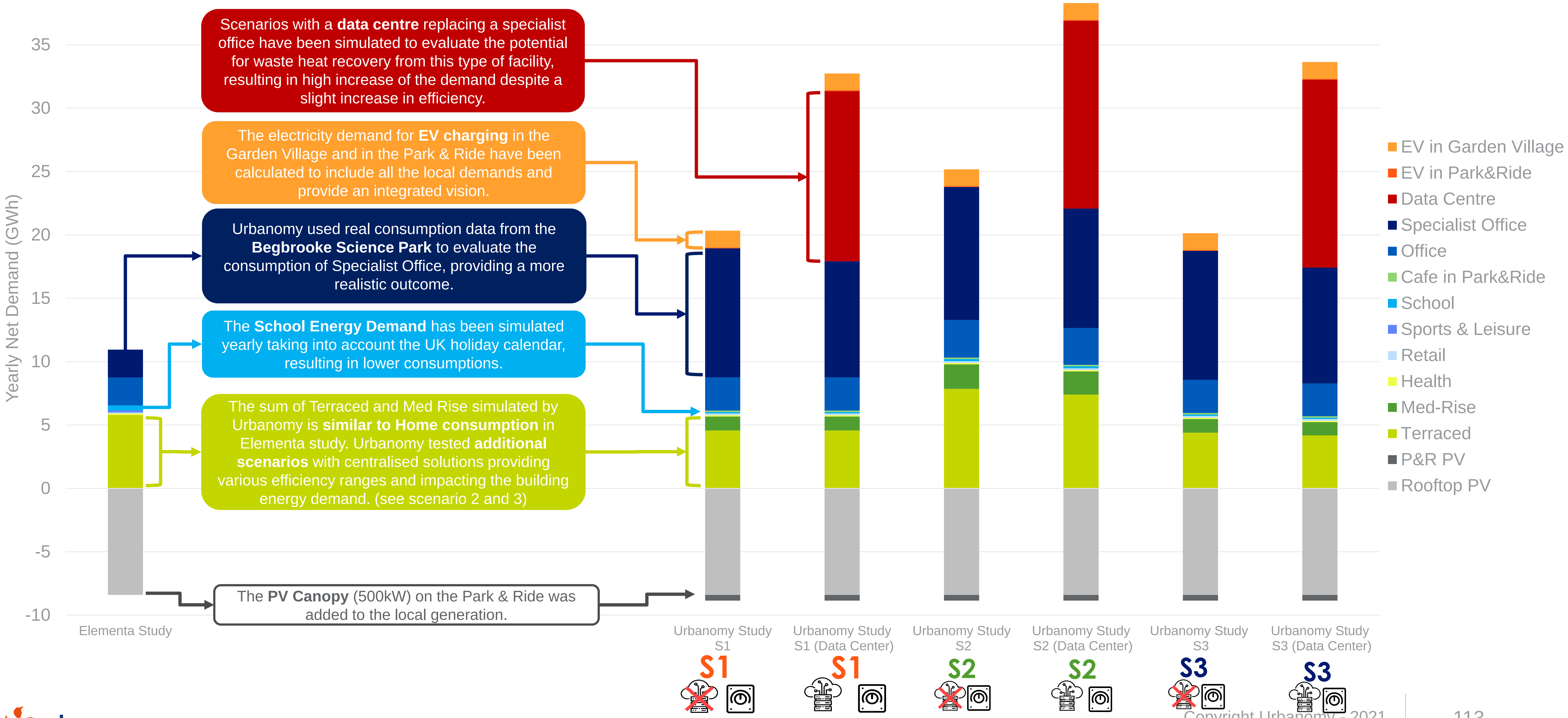


Net demand per scenario (w. inverter system)

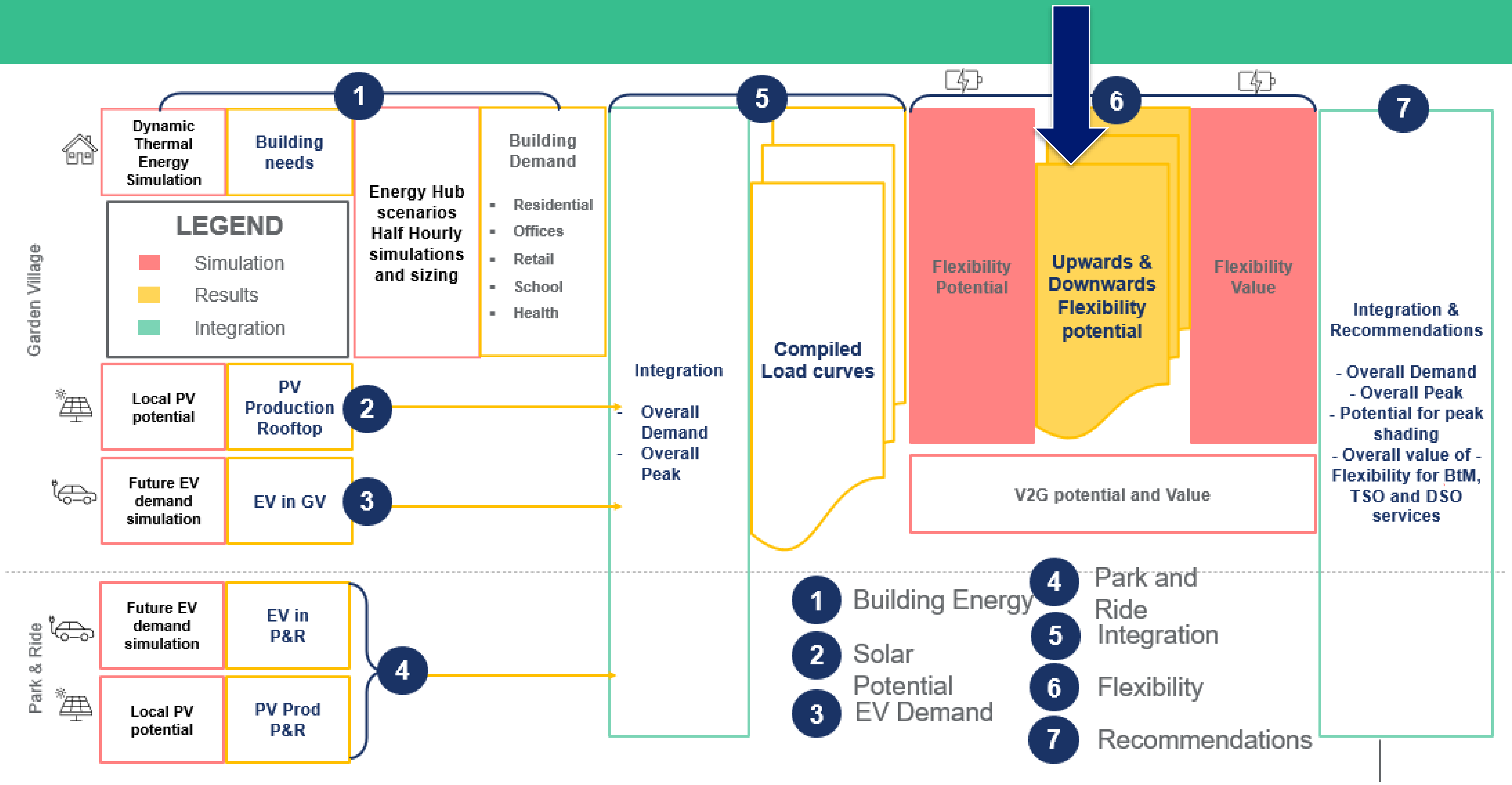
- Net demand per scenario (using the inverter control, which were shown to be more efficient), using the EV case 3 scenario (38% EV market penetration inc. rapid charging) The
- Elementa study (May 2020) results have also been shown for comparison, including the overall consumption and generation.
- The overall energy consumption is higher in this study because the specialist office is based upon real values (extrapolated from Begbroke Science Park), and the EUI of each typology is higher due to the detailed simulations considering unregulated electricity and seasonality. The data centre has also been considered, which has a high energy usage.



Net demand per scenario (w. inv. system) – Comparison/Validation

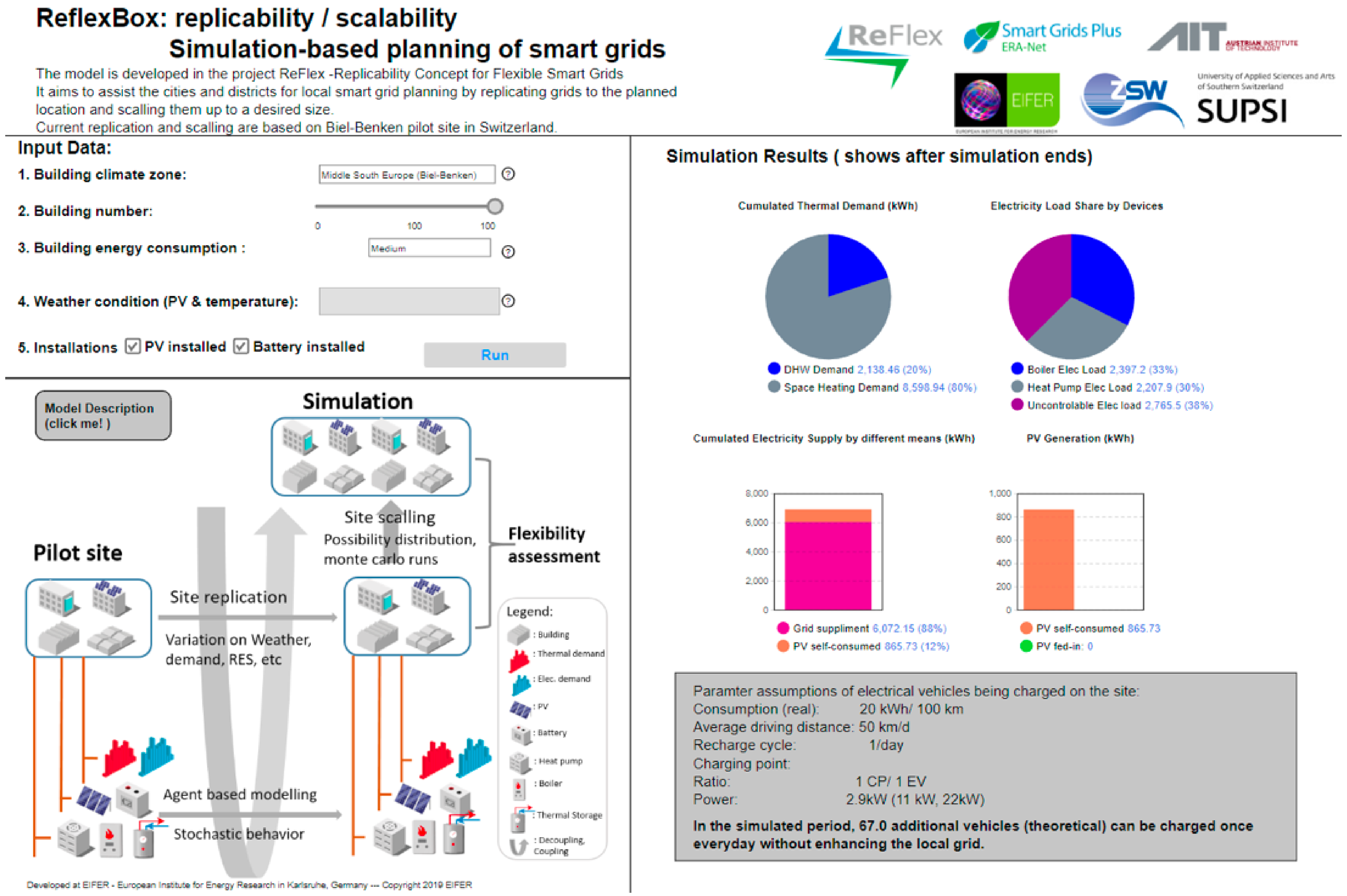


6. 1. Flexibility
Potential in buildings



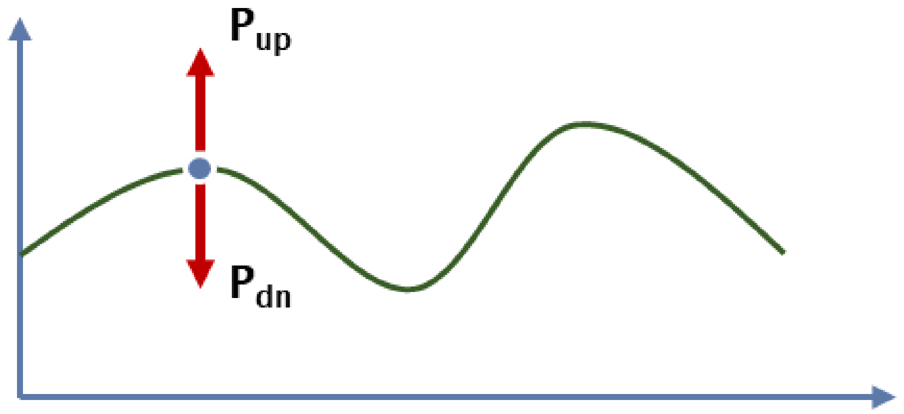
The ReFlexBox Tool

- Simulates the operation of energy systems, consisting of single buildings located in the same grid area
- The tool assesses the flexibility potential of the designated area
- This allows to optimize and scale up best practice technologies.
- The replicability potential is based on experiences obtained in +10 smart grid demonstration projects of the ReFlex Project.

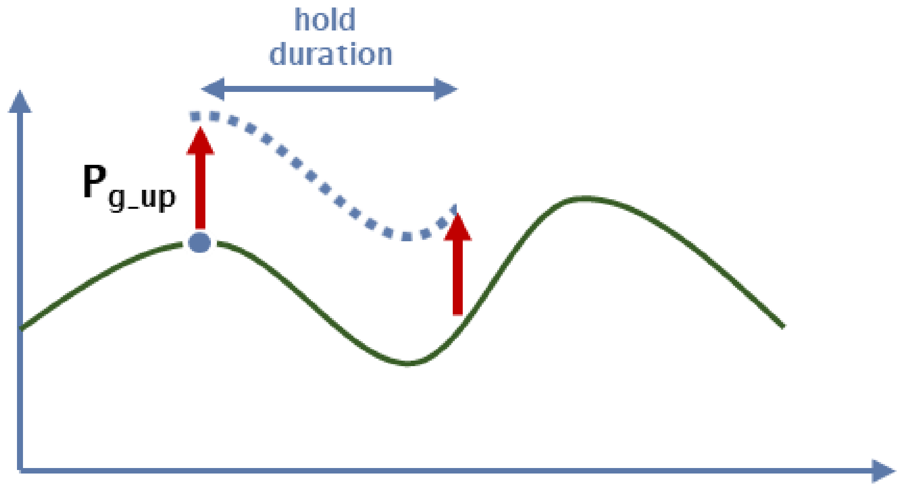


Flexibility Potential Types

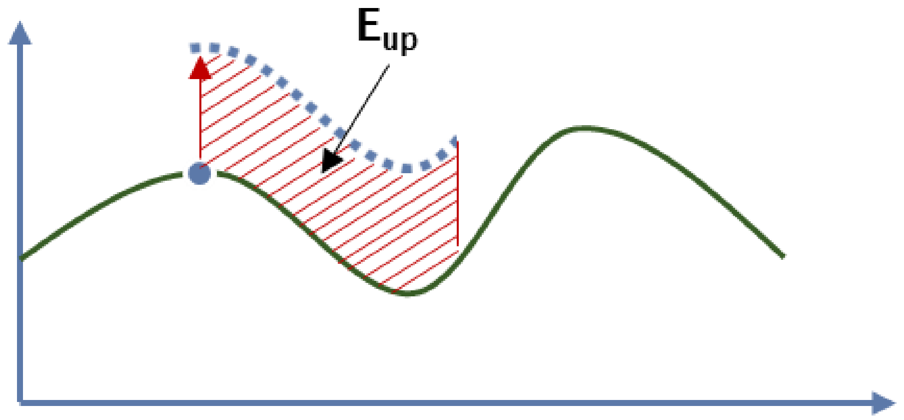
1. **In total power** (absolute potential):
   – Power that could be momentarily activated without any constraints (storage state, demand not considered)



2. **In guaranteed power** (usable potential for EVs):
   – Power potential that can be held during a predefined time duration (input). In this case, the duration of an average daily EV charging process (68 min, results of the EV charging hypothesis), considers prediction of demand



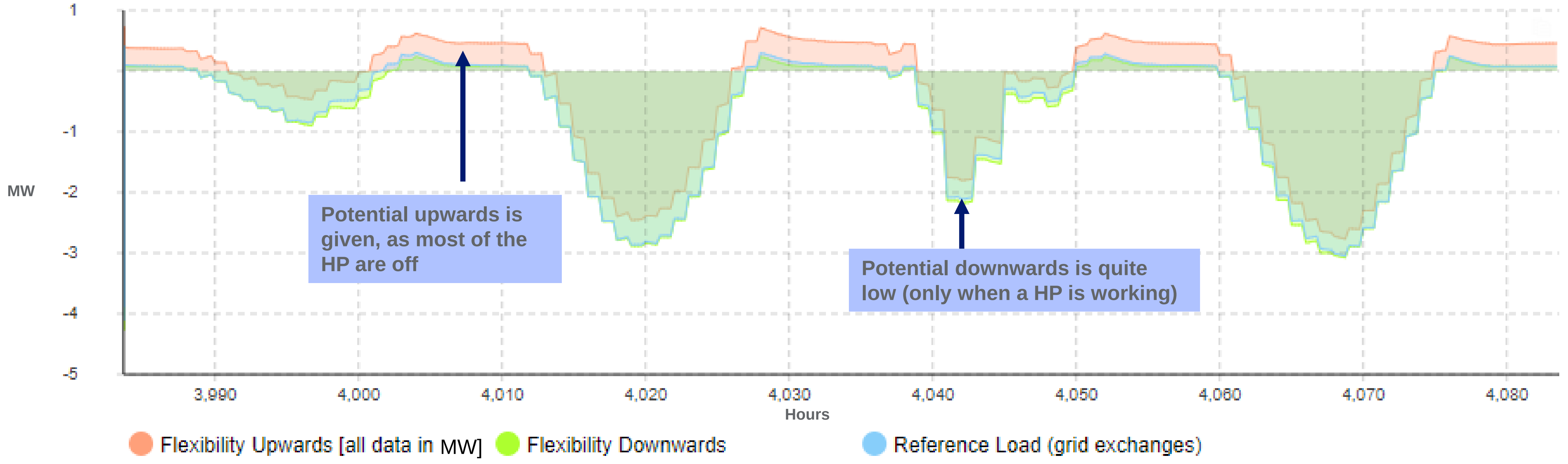
3. **In flexible energy** (absolute potential):
   – Total energy that can be shifted, without considering any power or time limits. Is calculated based on the current SOC and the prediction of the demand

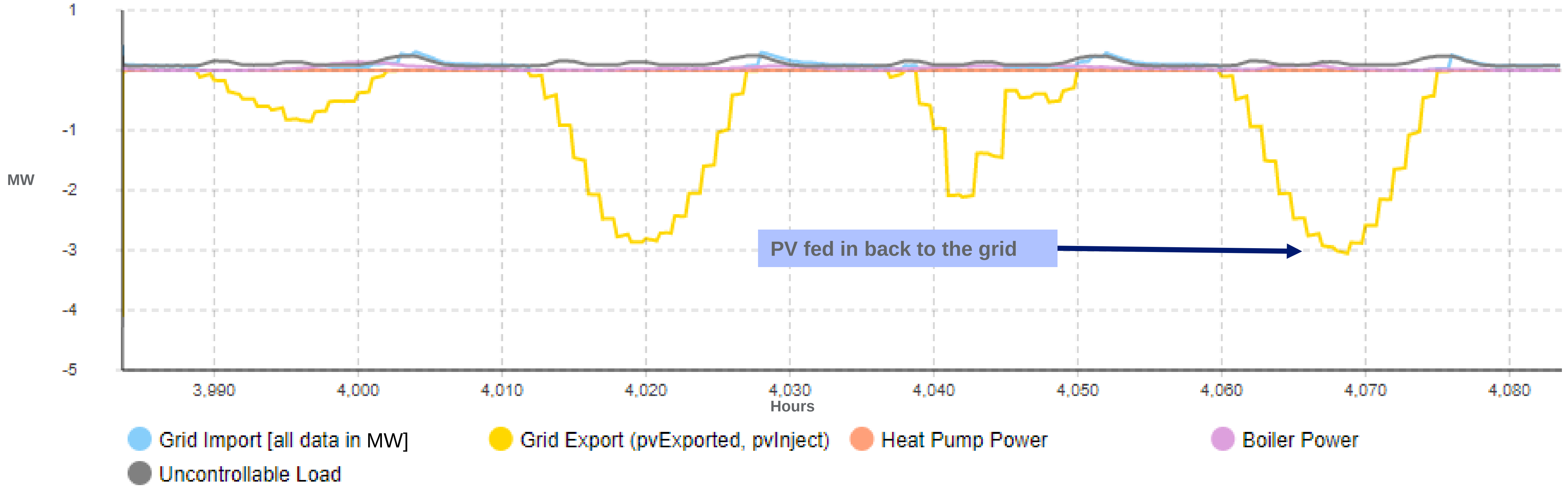


- **Upward Flexibility – Increase of consumption** (e.g. heat pumps could be turned on)
- **Downward Flexibility – Decrease of generation** (e.g. heat pumps can be turned off)

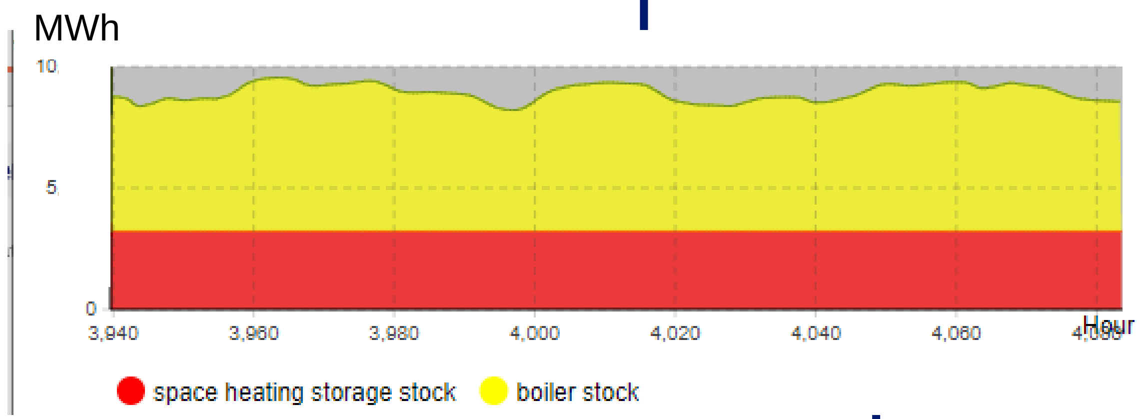
Flexibility Potential Example

- **Typical summer day in Oxford weather conditions, high storage example)**





DHW Storage is quite full most of the time



SPH storage is not used (no heating)

Flexibilty Simulation Cases

1. Baseline
   – Scenario for detached houses based on Scenario 1 ON-OFF of the Energy Study

2. Increased heat storage
   – Increase of the thermal storage for space heating

3. With batteries
   – Addition of a 3kWh battery to each home

4. Heat storage + batteries
   – Combination of measure 2 and 3

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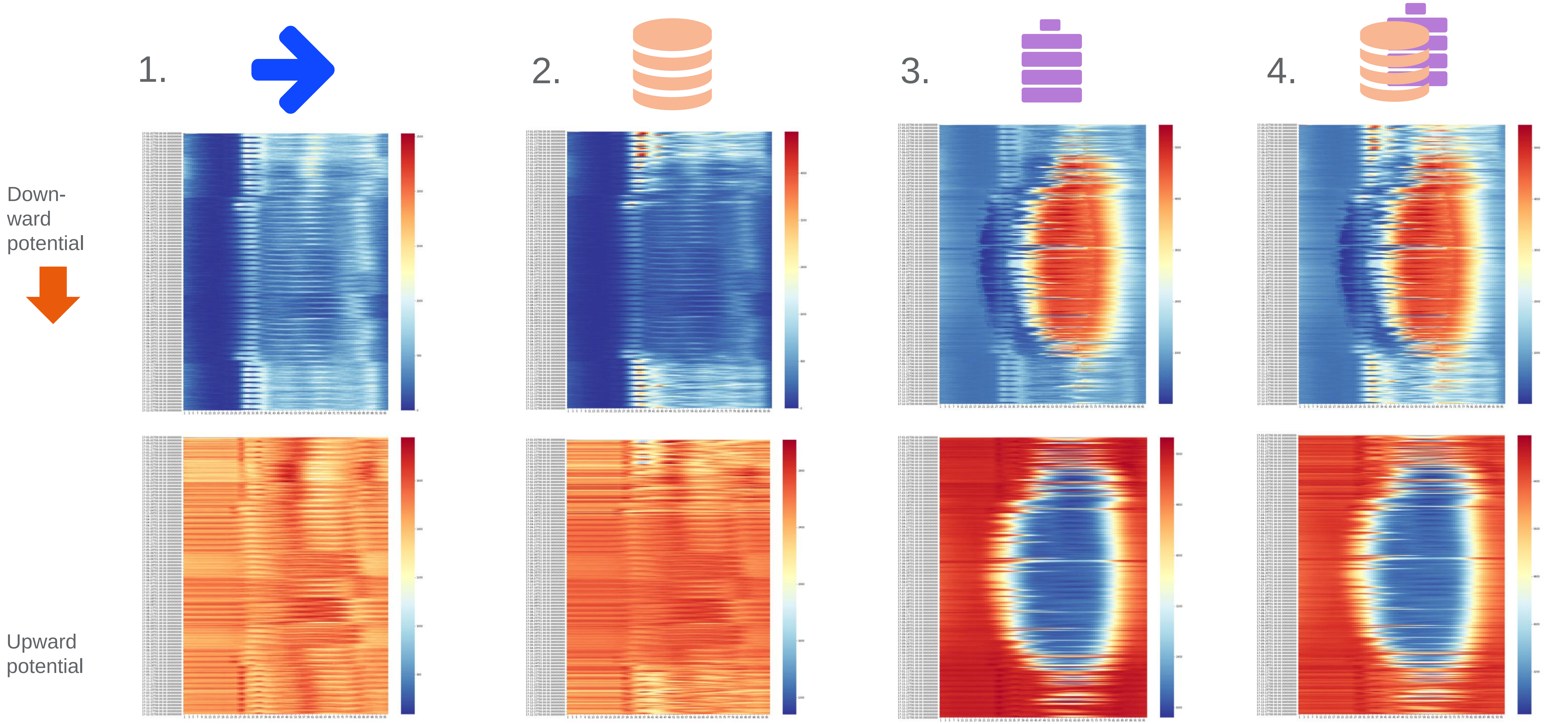
Synthesis of results

- Number of EVs that can be additionally charged without increasing demand.

1. Baseline — 57
2. Increased heat storage — 62 — + 9%
3. Added batteries — 138 — + 142%
4. 2+3 combined — 143 — + 151%

Synthesis of flexibility potential mapping

- Energy flexibility potentials up- and downwards for all cases*



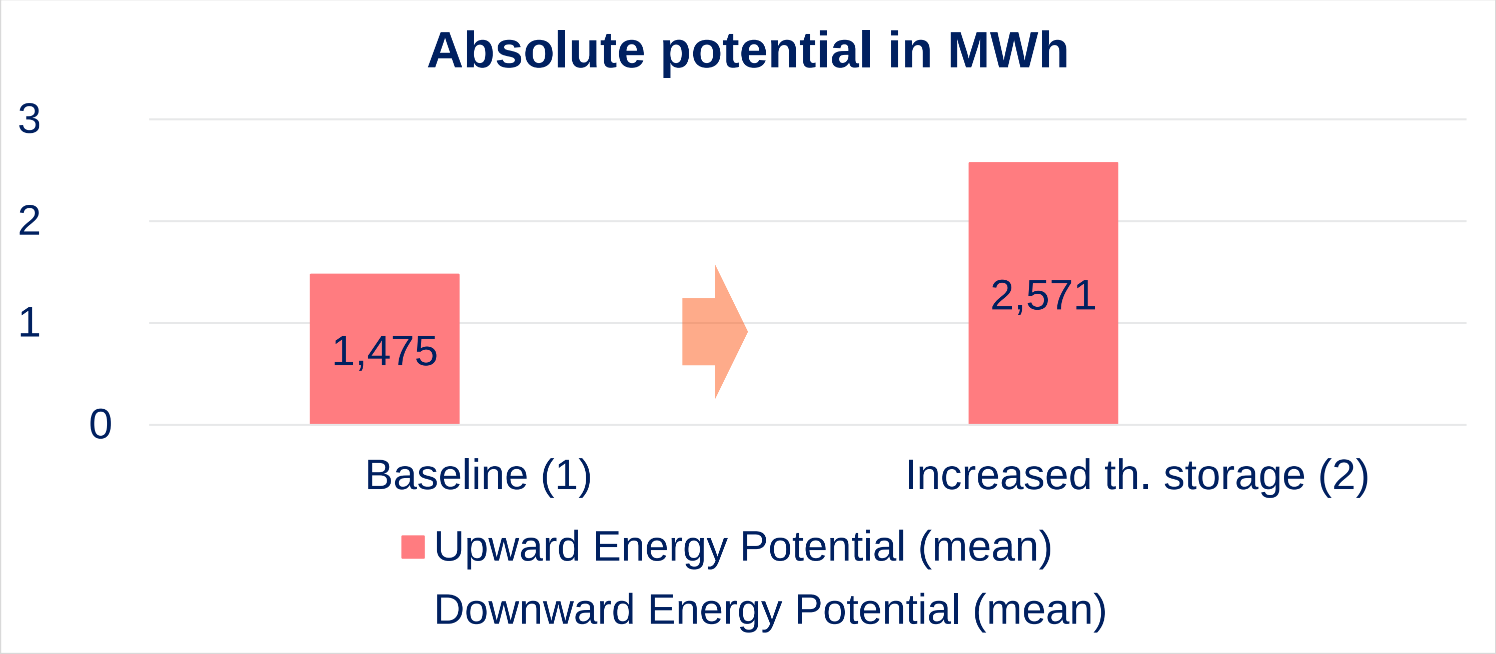
Low baseline situation **Slight increase** **Strong increase with high correlation with solar**

*for visualisation purposes, color scales are relative to each plot and not absolutely comparable (see scaling in previous plots)

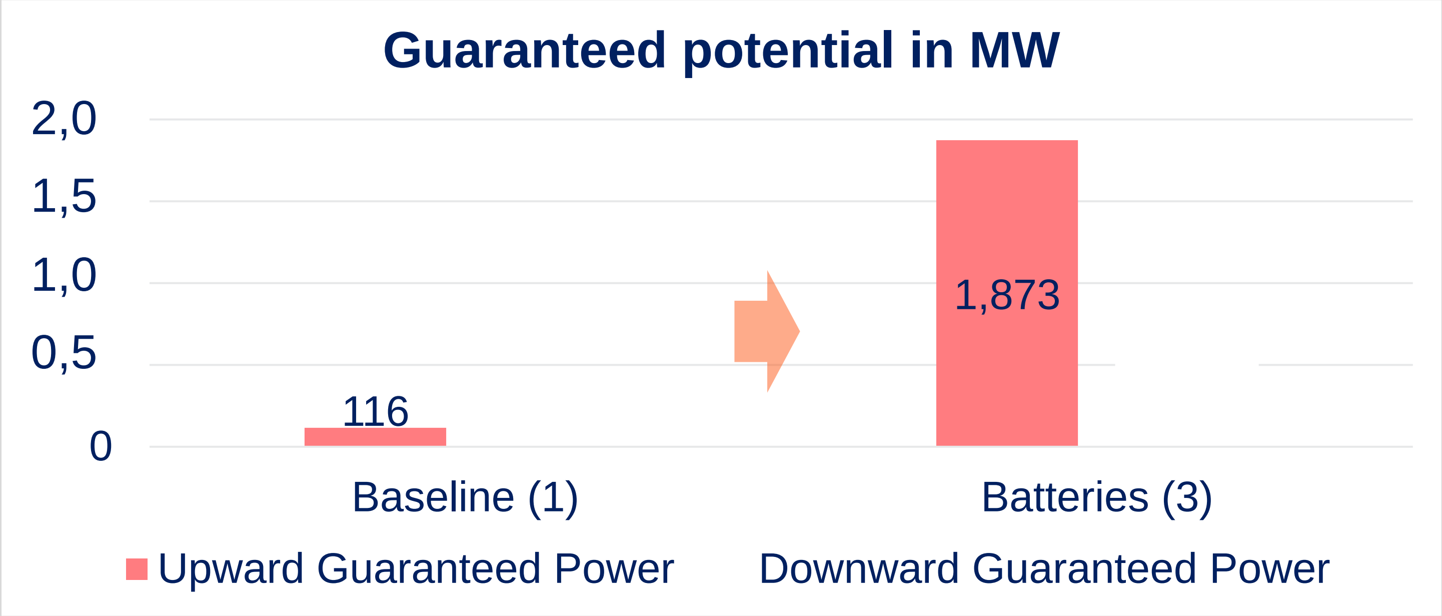
Synthesis of results

- Heat storage (2) & Batteries (3)

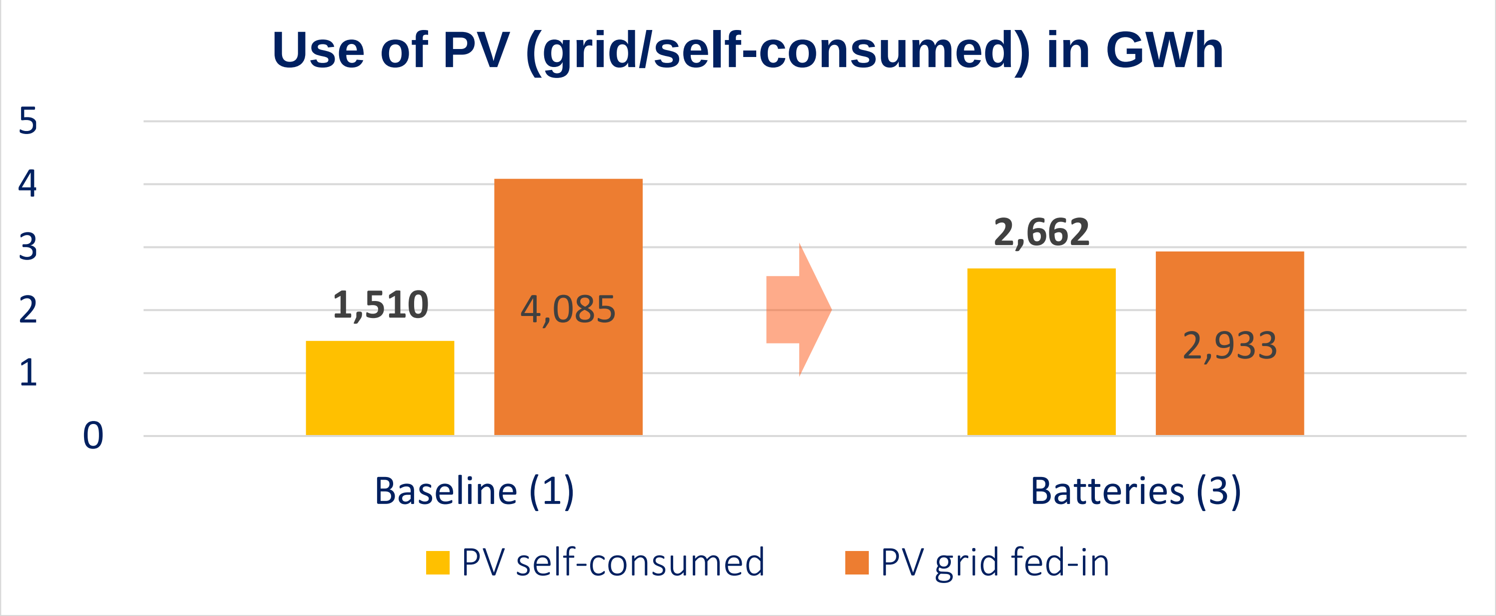
- Increased heat storage leads to additional flexibility potential
  In terms of absolute energy potential up and downward
  In terms of downward guaranteed power potential adding 9% more EVs
- In general, the heat storage has low effect, as the flexibility emerging from heat pumps is not very large due to their low consumption and sizing.



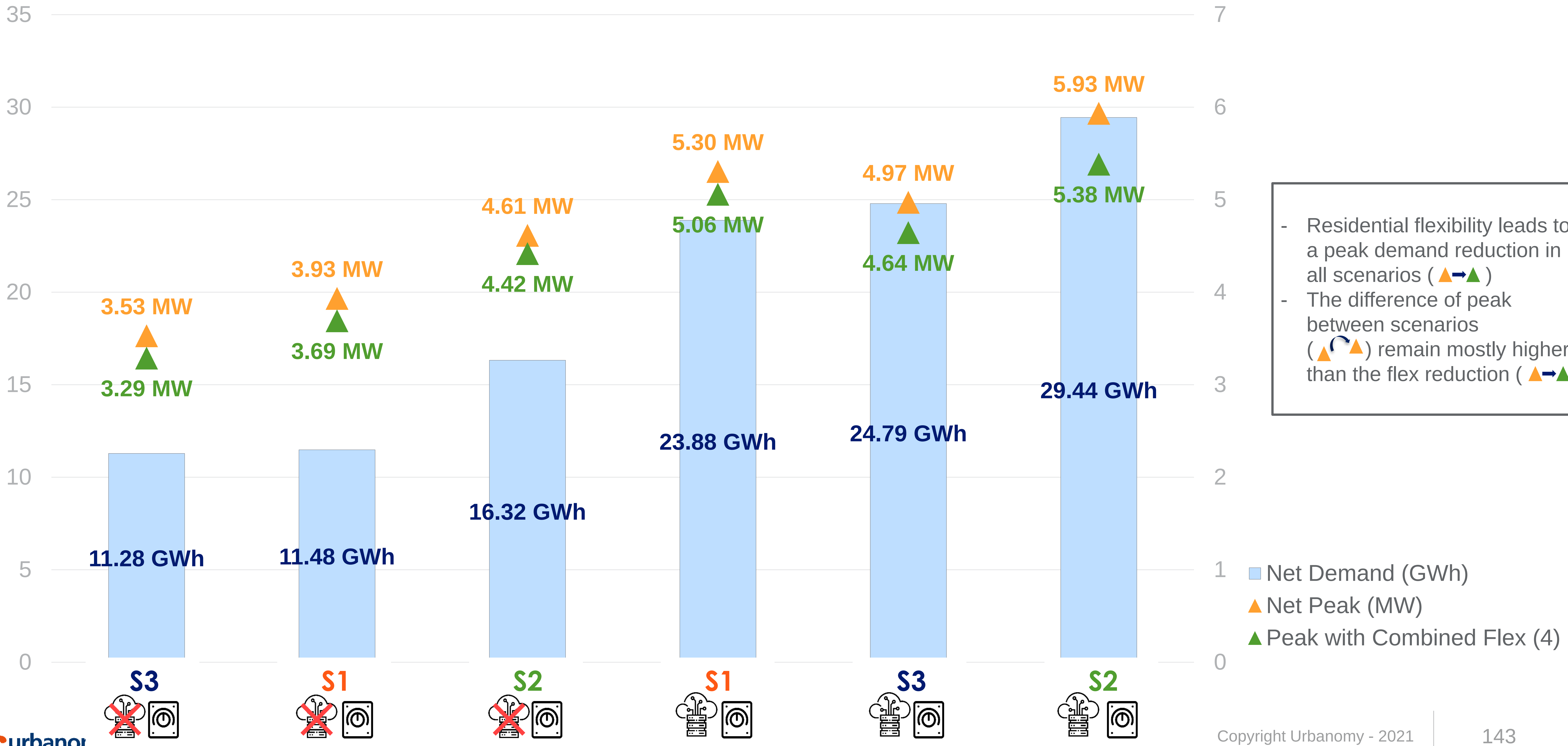
- Adding relatively small-sized batteries can **increase the potential considerably (x10)**.



- **Self consumption** is increased by 76% with batteries



Peak Reduction from Residential Flexibility



- Residential flexibility leads to a peak demand reduction in all scenarios (▲➡▲)
- The difference of peak between scenarios (▲ ▲) remain mostly higher than the flex reduction (▲➡▲)

Comments and recommendations (1/2)

01

Thermal demand vs. electricity demand

The highly efficient thermal systems, show a very low heat demand. The thermal demand is quite low compared to the electricity demand – which is usually the opposite in most district energy. This special situation leads to a low flexibility potential in the baseline, and it is only slightly increased when adding an additional thermal storage of 250l to the space heating systems. Even with large storages, the relatively low installed powers make this energy potential not usable, thus maintaining a low power flexibility potential.

04

Downward power potential

Downward power potential is always available, allowing to charge additional vehicles by shifting the load due to heat pump stopping at the charging time. Downward energy potential is also useful when other loads would enter the system at critical peak times. In this case the terraced houses could reduce their loads and shift energy consumption to later moments.

02

Batteries & flexibility

Batteries show the largest effect on flexibility potential as they provide a real flexibility lever in both terms of energy and especially power.

05

Upward power potential

Upward energy potential can be useful to absorb renewable electricity from other parts of the district for shorter durations than the minimum guaranteed value: e.g., if there is a CHP generating electricity, or if other parts of the district would increase their PV share.

03

Absolute upward energy potential

Absolute upward energy potential is relatively high compared to power potential, as it considers the theoretical available thermal capacity in the heat storages, as well as the spare capacity in the batteries (in scenario 3-4).

Comments and recommendations (2/2)

06

Storage systems

The system simulated for Salt Cross Garden Village shows a low flexibility in the baseline simulation, but it can be considerably and effectively increased by electrical storage (i.e. batteries).

07

Increased flexibility potential

Increased thermal storage measures are only reasonable if the heating systems are largely sized. The use of batteries is recommended, as it allows to increase both PV self consumption and flexibility provision.

08

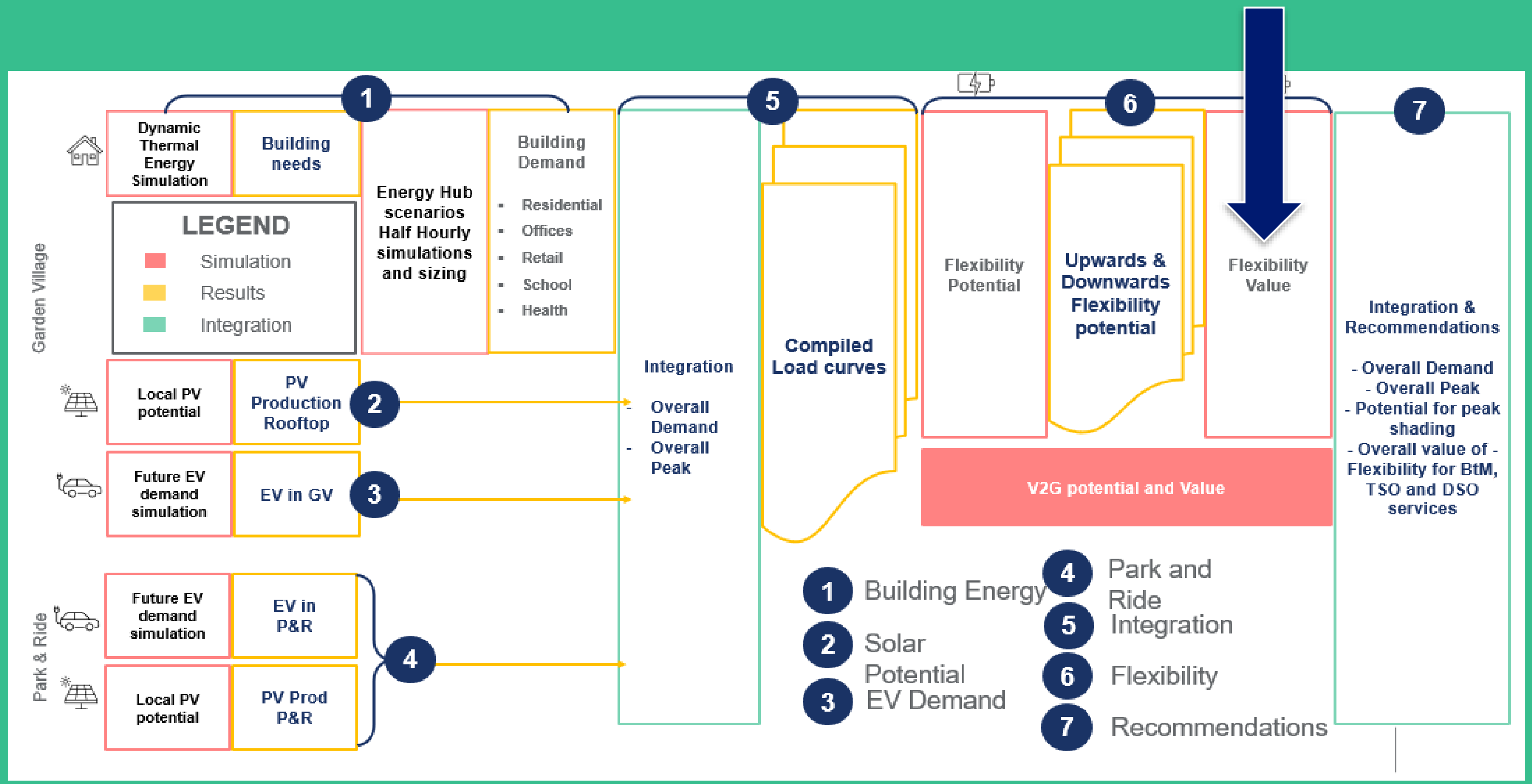
Maximisation of local self-consumption

Local self-consumption of the Salt Cross Garden Village can be optimised by combining PV and power-to-heat storage to harvest most of the solar electricity by the heat pumps.

09

Energy management systems

In order to harvest the flexibility potential, an energy management system should be set up for the district. This system should be well dimensioned, as it needs to be able to manage many small assets : more than 1500 individual heat pumps are expected and eventually batteries as well.



6.2. Flexibility

Residential flexibility revenues

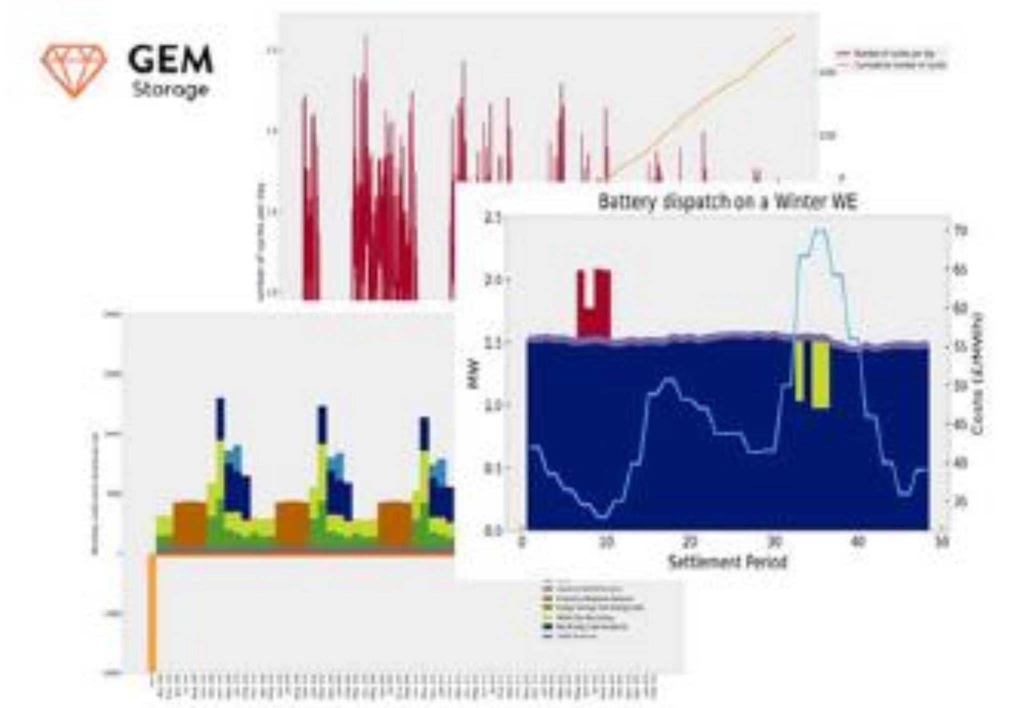
In this section, the potential savings and revenues have been evaluated for the residential flexibility evaluated in the previous section.

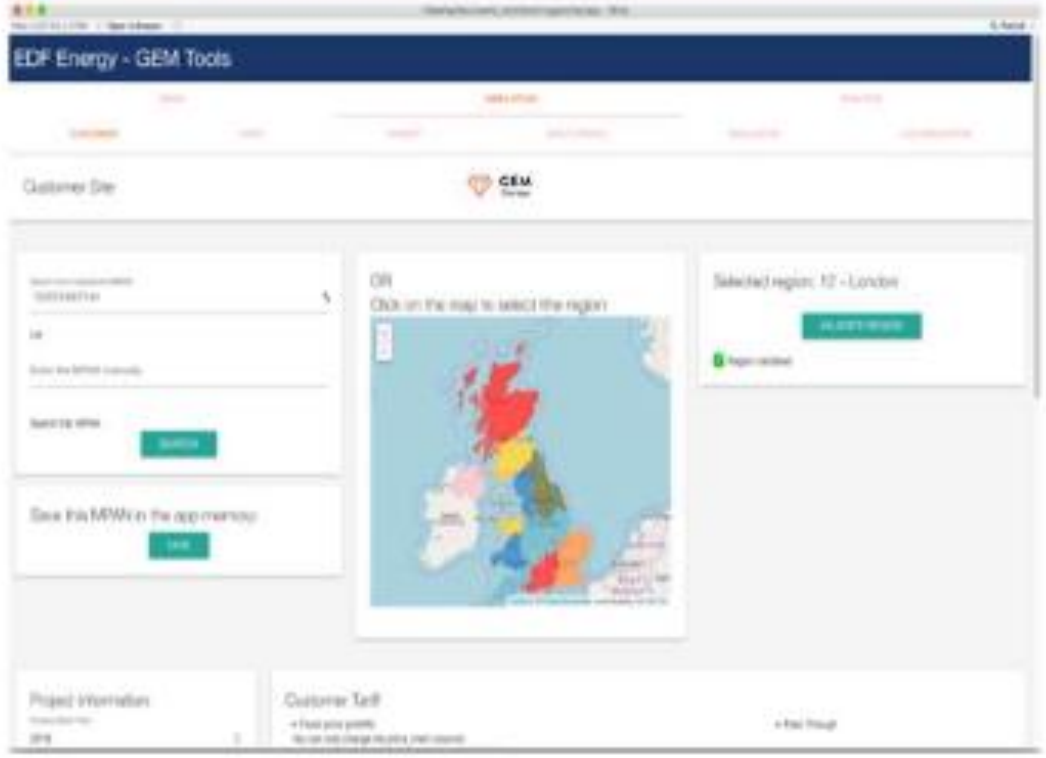
Grid Energy Management (GEM) Optimisation tool

GEM-Storage tool (Grid Energy Management), is a **2-stage optimisation model** developed through a rolling horizon to evaluate the business case for energy storage assets in stand-alone configuration or co-located with a low carbon generator.

The model determines the **optimum (combined) asset(s) operation based on price signals** from various markets / services, namely: Day-Ahead market, Intraday market, Frequency Response service, Balancing Mechanism and non-energy energy costs. Fundamentally, and based on the various price signals, the model will determine the optimum operational strategy and quantify the associated revenue streams, over the assets lifetime.

Moreover, 4 **battery degradation** options are included in the model and available for selection based on user input – including linear and bespoke degradation options.





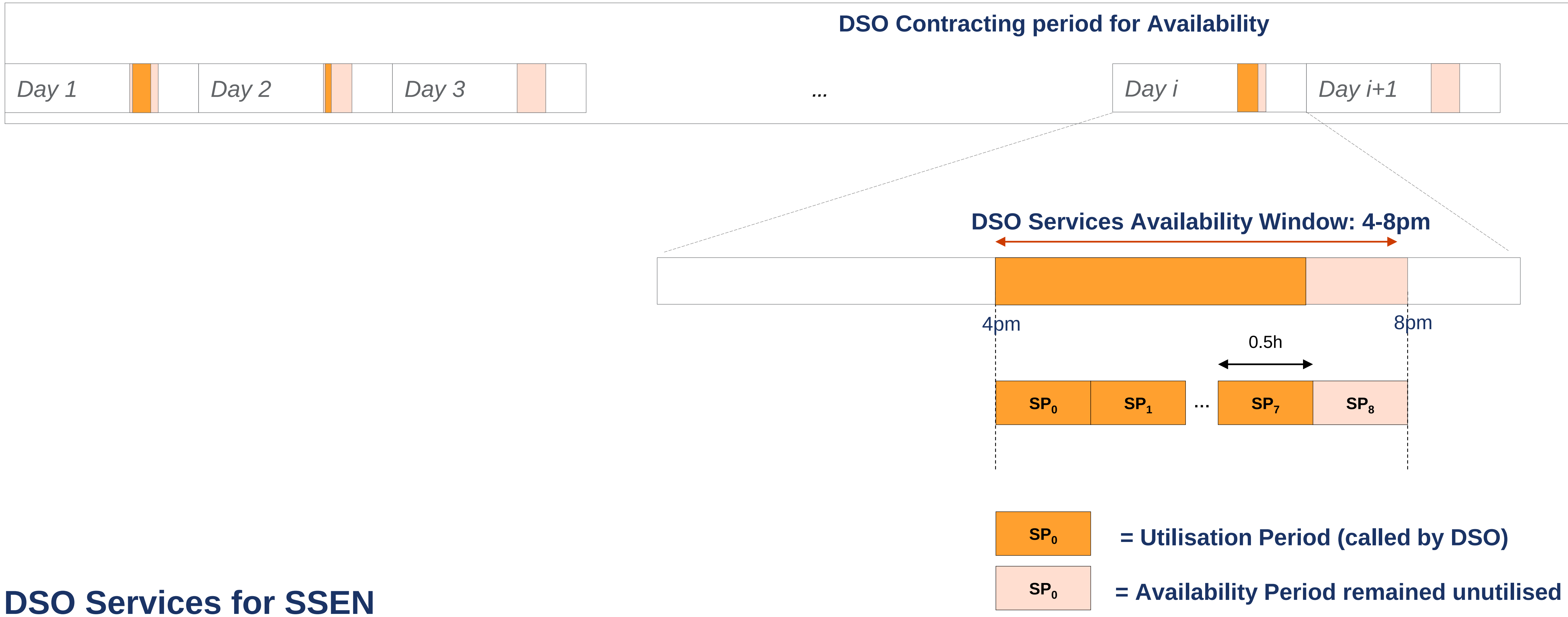
Multi-Service Business Model: Definitions of the services

Arbitrage

Day-Ahead (DA) Market Arbitrage	Optimization of Non-Energy Costs (NECs)	DSO Flex. Service (DSO)	Frequency Response (FR)
• Seize price arbitrage opportunities	• Reduction of charges associated with NECs with specific electrical configurations • Option to include ROC (Renewables Obligations Certificates)	• Additional revenue stream by reducing peak load at the local network	• Provision is achieved in specific time blocks (i.e. EFA blocks) • Modelled implicitly and not optimised

Multi-Service Business Model: Definitions of the services

In the transition from DNO to DSO, the Local Energy Oxfordshire (LEO) project led by SSEN is defining a local energy market supporting the distribution network infrastructure. As part of this large-scale demonstrator project, SSEN defined a framework for DSO services, which have been implemented in this study and defined as below in accordance with SSEN's guidance.



where:
- SP: Settlement Period

DSO Services for SSEN

- The flexibility provider is contracting for a period of time during which he will provide asset availability during the Availability window. For example, he will contract for 20 days of availability per month over a period of 3 months (60 days of availability).
- The availability must be during the Availability Window between 4pm and 8pm. This represents 60 days x 4h = 240h of availability.
- The foreseen price for the DSO services is **£300/MWh for the utilisation of 20h** within the frame of the above structure. If less than 20h are called, the payment will remain of £300/MW. In other words, from a total of 240h of being available, the DSO expects to activate the flexibility asset to deliver the DSO service for up to 20h.
- The contract value = £300/MWh for 20h of expected utilisation x MW of flexibility offered
- For the sake of this study, we have considered an equivalent price in terms of £/MW/h for each settlement period equal to **£1.25/MW/HH** = (£300/MWh ÷ 240h)

GEM-Storage: Revenues / Costs Modelling

-Case 1-

Reference case

"Baseline"/Case 1 scenario considers a set of terraced houses based on Scenario 1 ON-OFF of the Energy

- Day-Ahead market prices
- DUoS
- BSUoS
- TNUoS / TRIADS

-Case 2-

Increased heat storage

Case 2 builds on scenario of Case 1 by considering an increased capacity in heat

- BSUoS
- TNUoS / TRIADS

-Case 3-

Energy Storage System (battery)

In Case 3 the flexibility potential comes from an

Revenues are composed by:

- Day-Ahead market prices
- Frequency response availability fees
- DSO services
- DUoS
- BSUoS
- TNUoS / TRIADS

-Case 4-

Combined thermal storage + battery

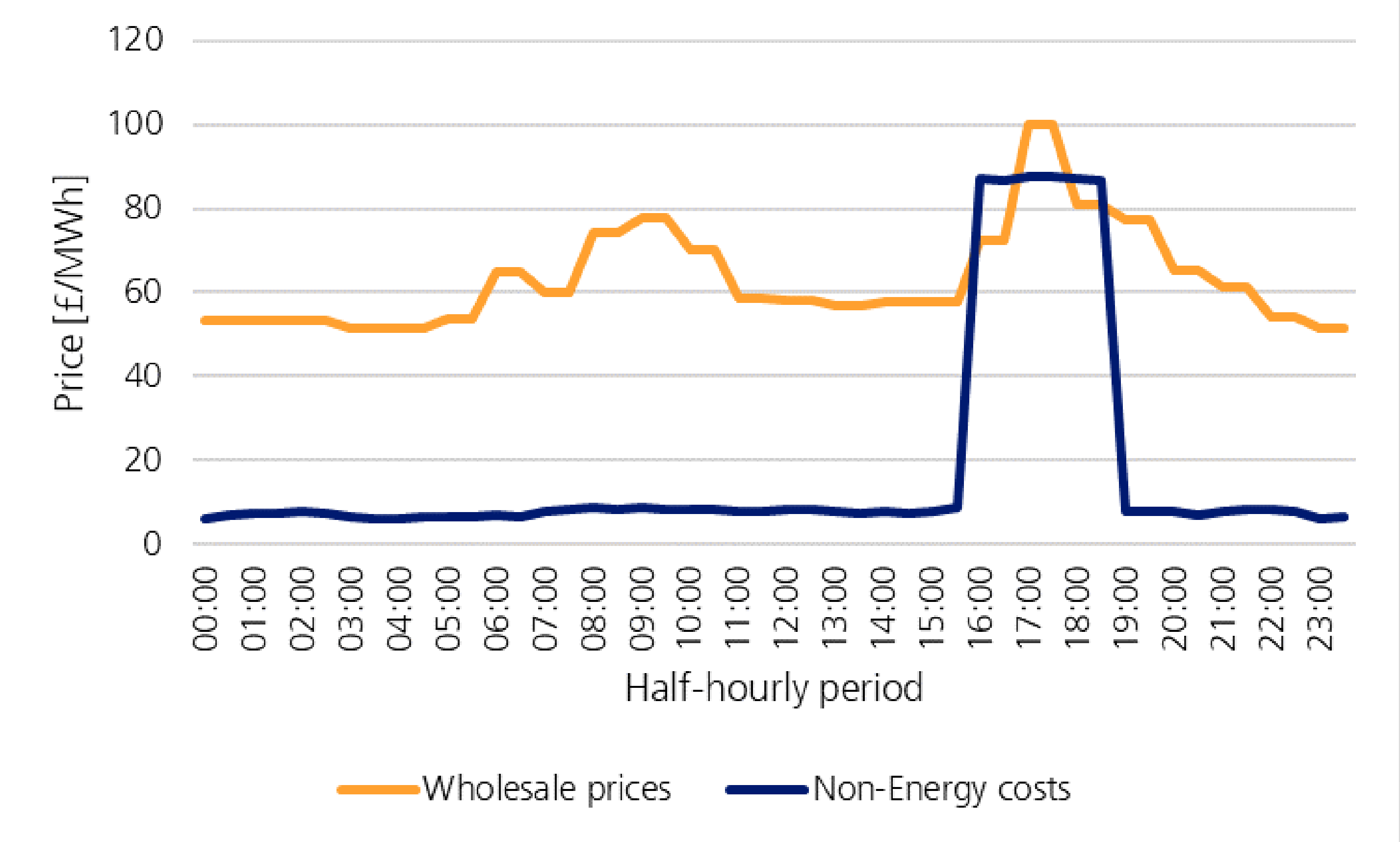
Case 4 exhibits a greater flexibility potential by considering an increased capacity in heat storage but also a residential battery. Costs / Revenues streams are composed by:

- Day-Ahead market prices
- Frequency response availability fees
- DSO services
- DUoS
- BSUoS
- TNUoS / TRIADS

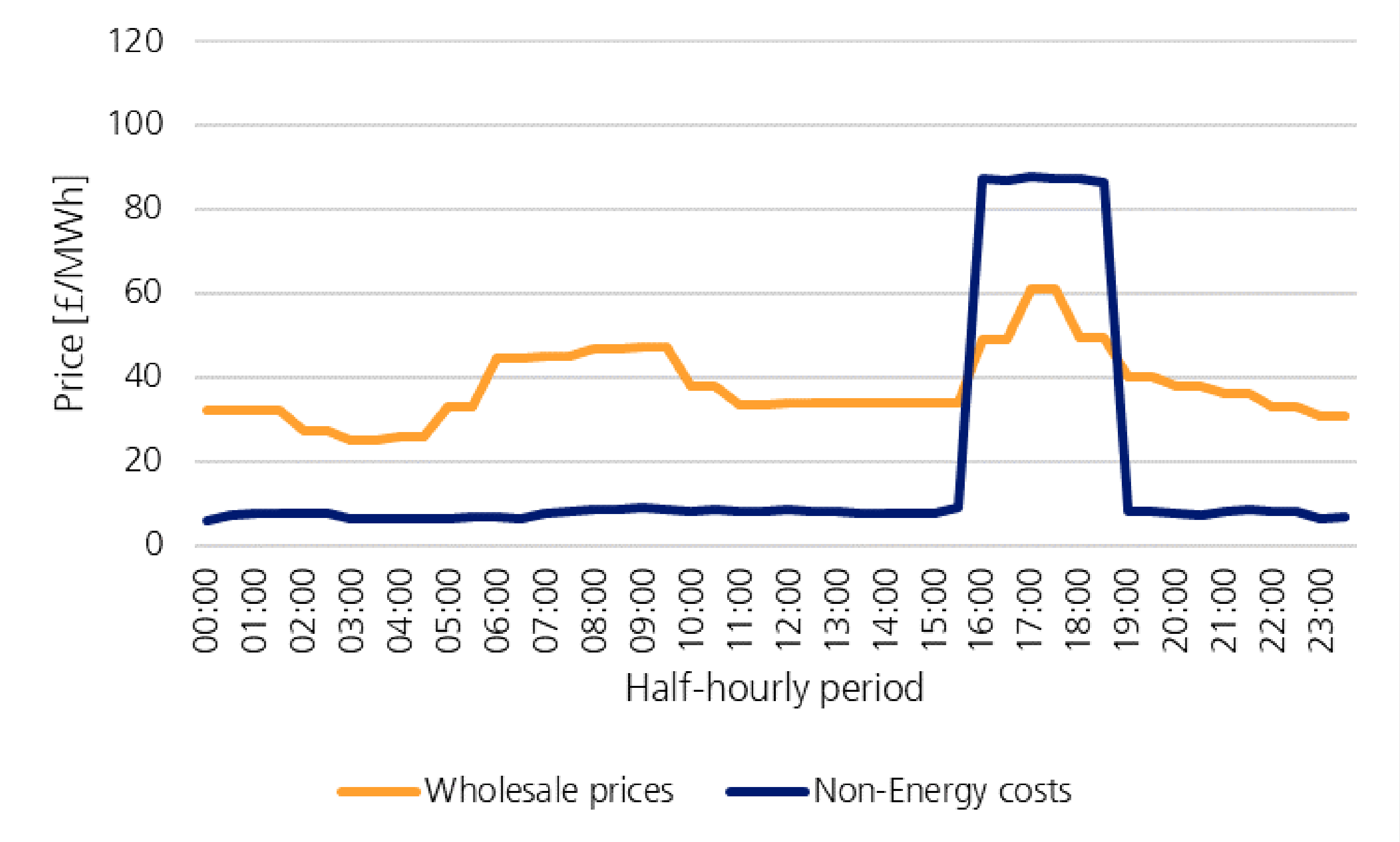
Case 4 integrates the highest potential for flexibility and has been highlighted here to display the highest revenues.

Input Data: Market Data & Assumptions

Daily evolution of the market prices for a typical day in Winter (£/MWh)



Daily evolution of the market prices for a typical day in Summer (£/MWh)



Note that wholesale prices during Summer are usually associated with lower prices in absolute terms but also less volatility, when compared to Winter market conditions.
Non-Energy Costs are associated to a specific DNO area (here Southern zone 10).

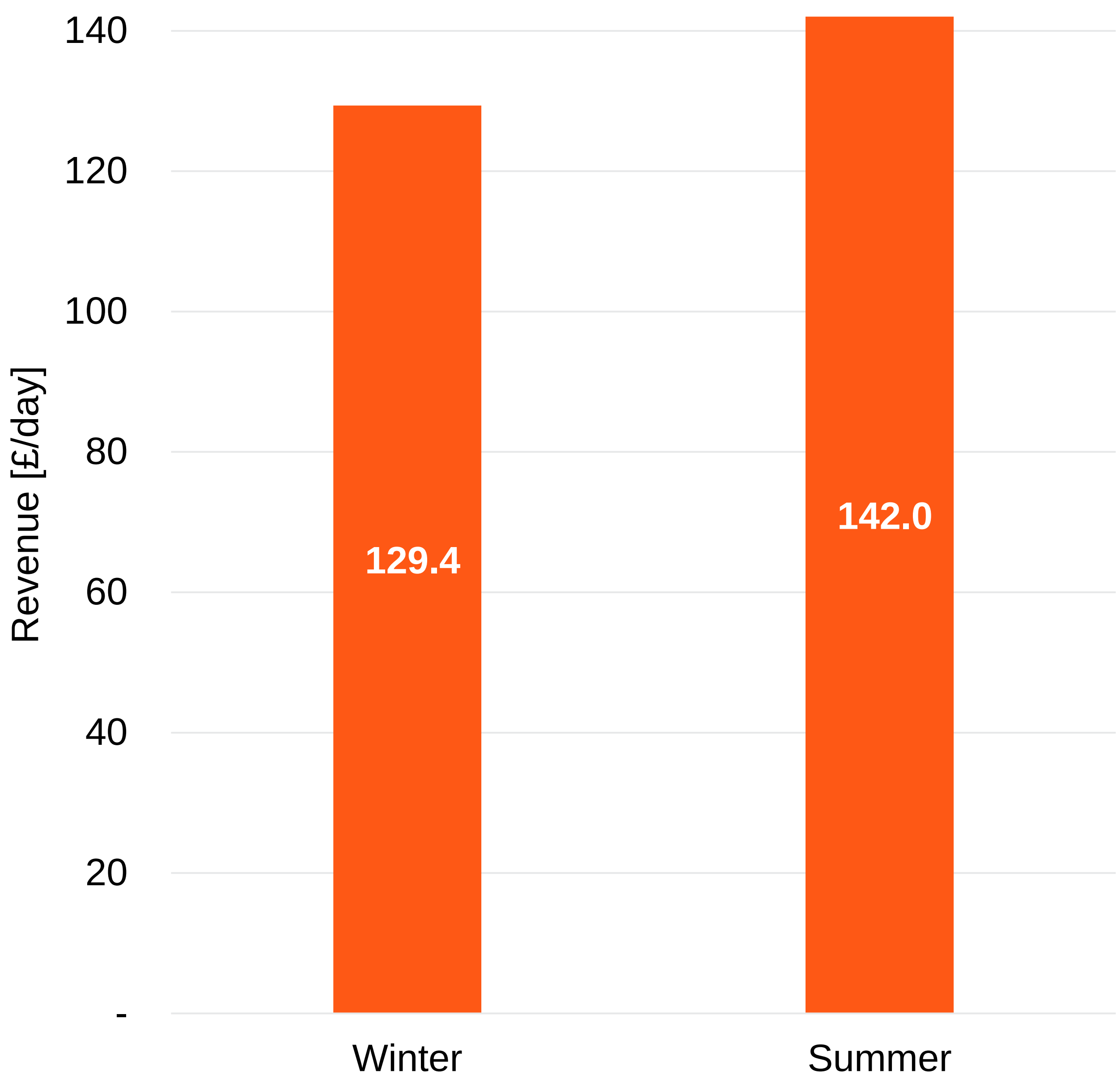
Flex. Service	Price [£/MW/h]	Start time	End time
Freq. Response[1]	4 / 6 / 10[2]	03:00 h	07:00 h
DSO	1.25[3]	16:00 h	20:00 h

[1] – Frequency response service is based on FFR product from National Grid (more info here). Service delivery was considered during EFA block 2.
[2] – Availability price based on current market conditions for FFR product.
[3] – Maximum availability price expected for LEO flexibility market, confirmed by SSEN.

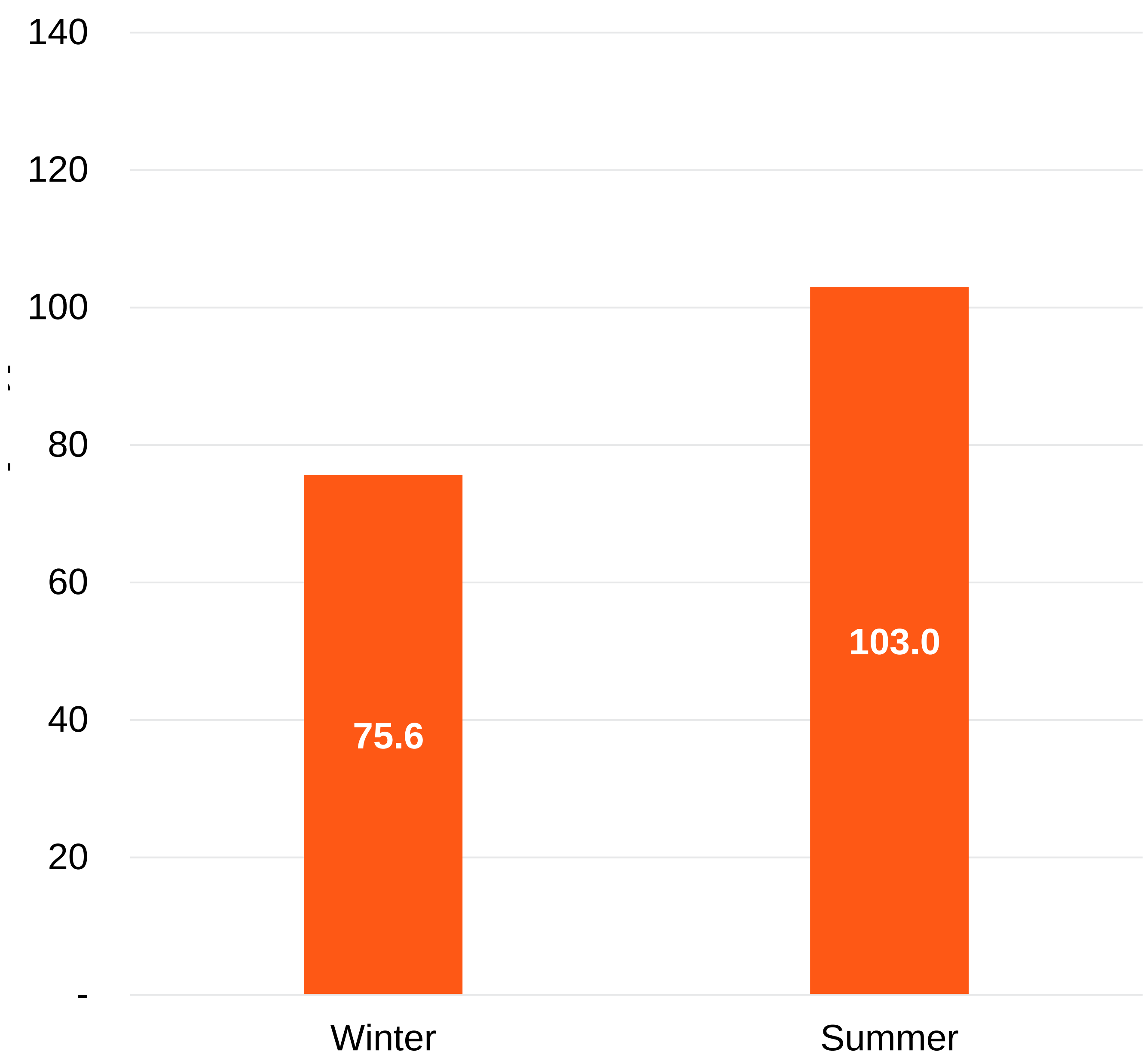
Results Case 4 – Economic Benefits

Case 4 - Daily revenue per day in pounds for a typical day in Winter and Summer

Favourable Market Conditions



Average Market Conditions

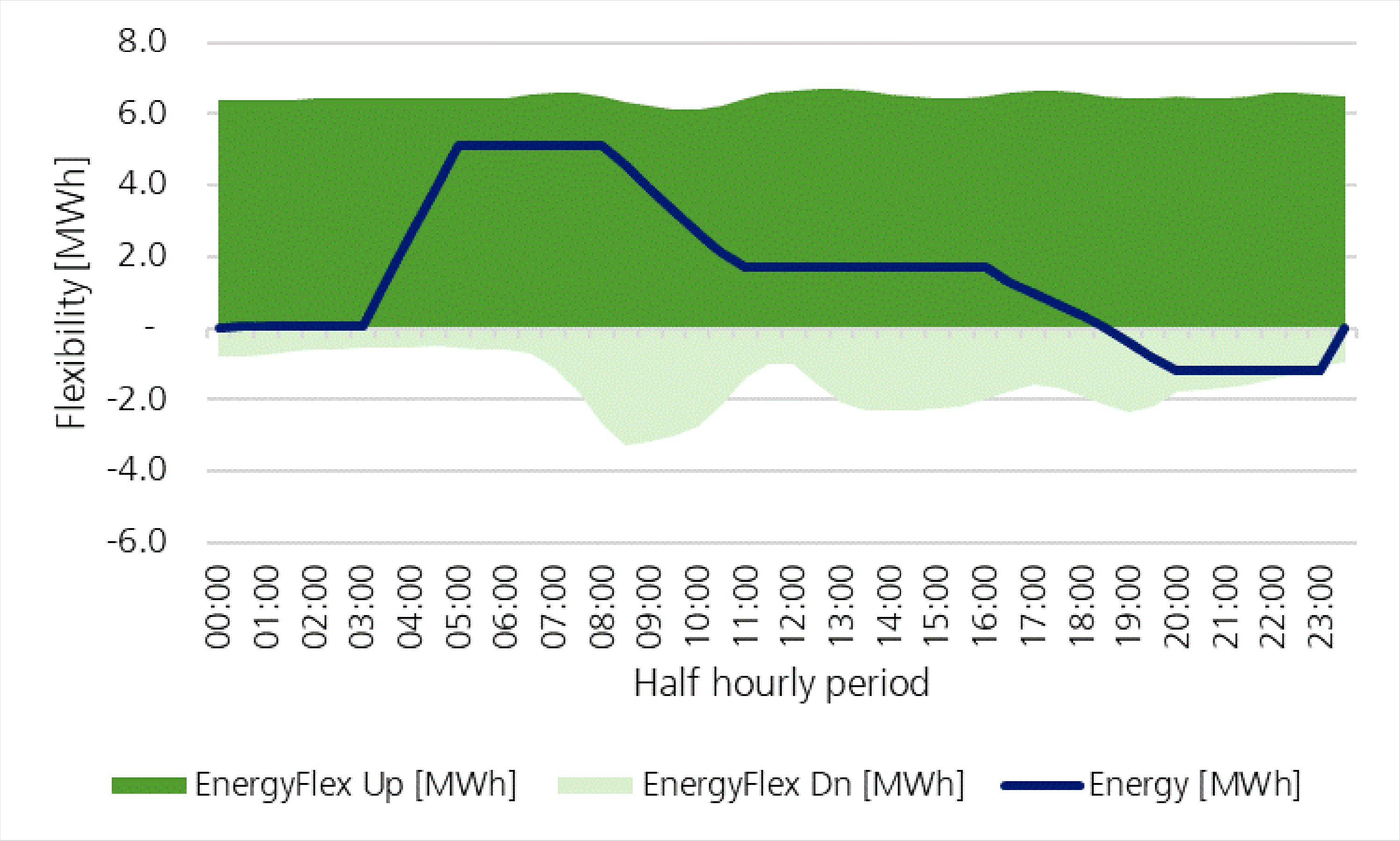


- **Case 4** has been defined as the combination of Case 2 and Case 3, with the combination of thermal storage and battery storage. This allows for higher volumes of energy and power flexibility, and therefore **higher revenues** (especially in Summer).

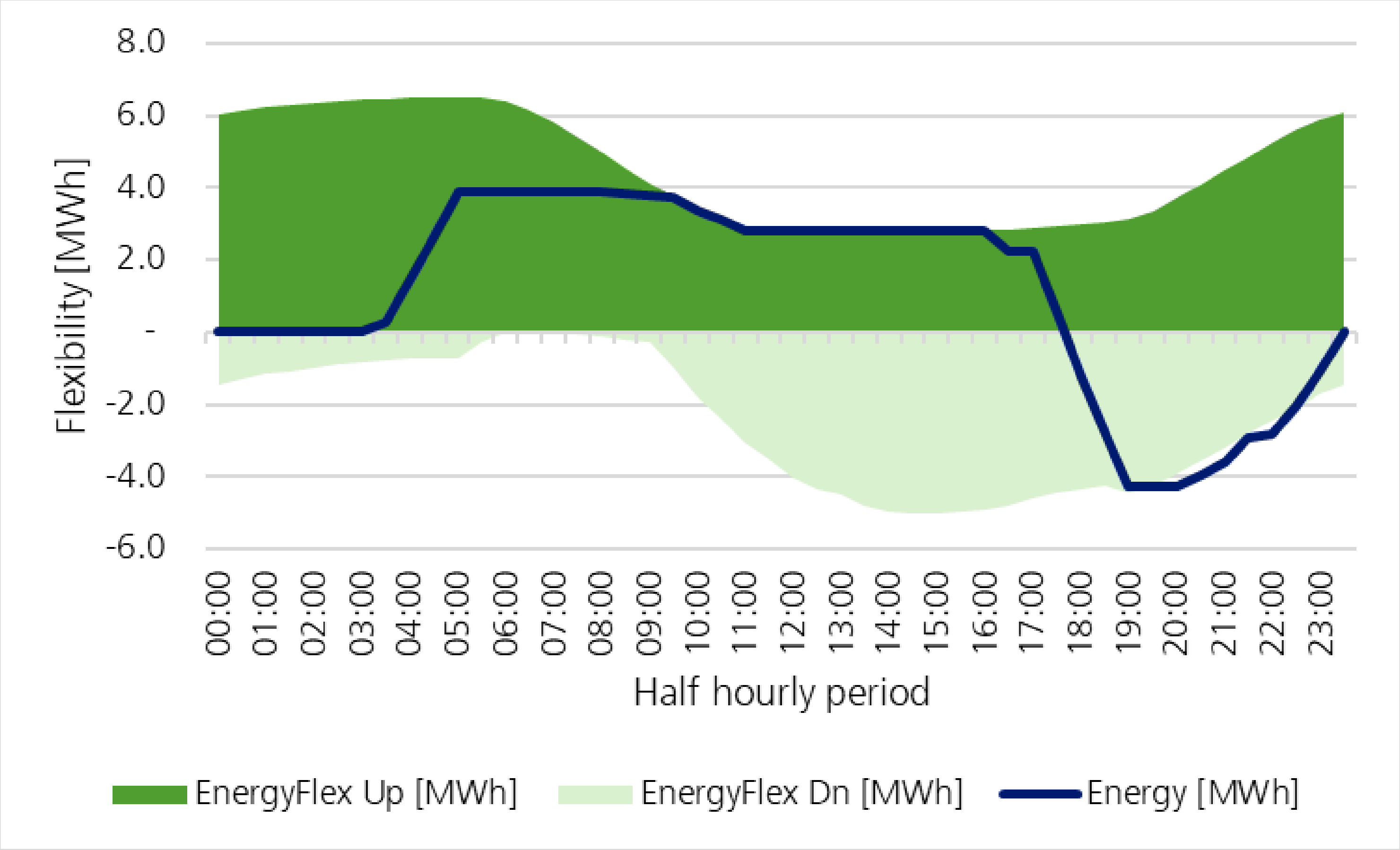
  Comparatively to Cases 1 and 2, Case 4 exhibits an inverted trend for seasonal revenues; **Summer revenues, are typically higher than in Winter** due to:
  - **Higher volumes of flexibility available, due to lower energy requirements (e.g. heating not required)**
  - **Increased production from PV plants, that are also complemented by the opportunity the battery offers**

Results Case 4 – Flexibility profile

Evolution of the energy flexibility profile for a typical day in Winter (MWh)



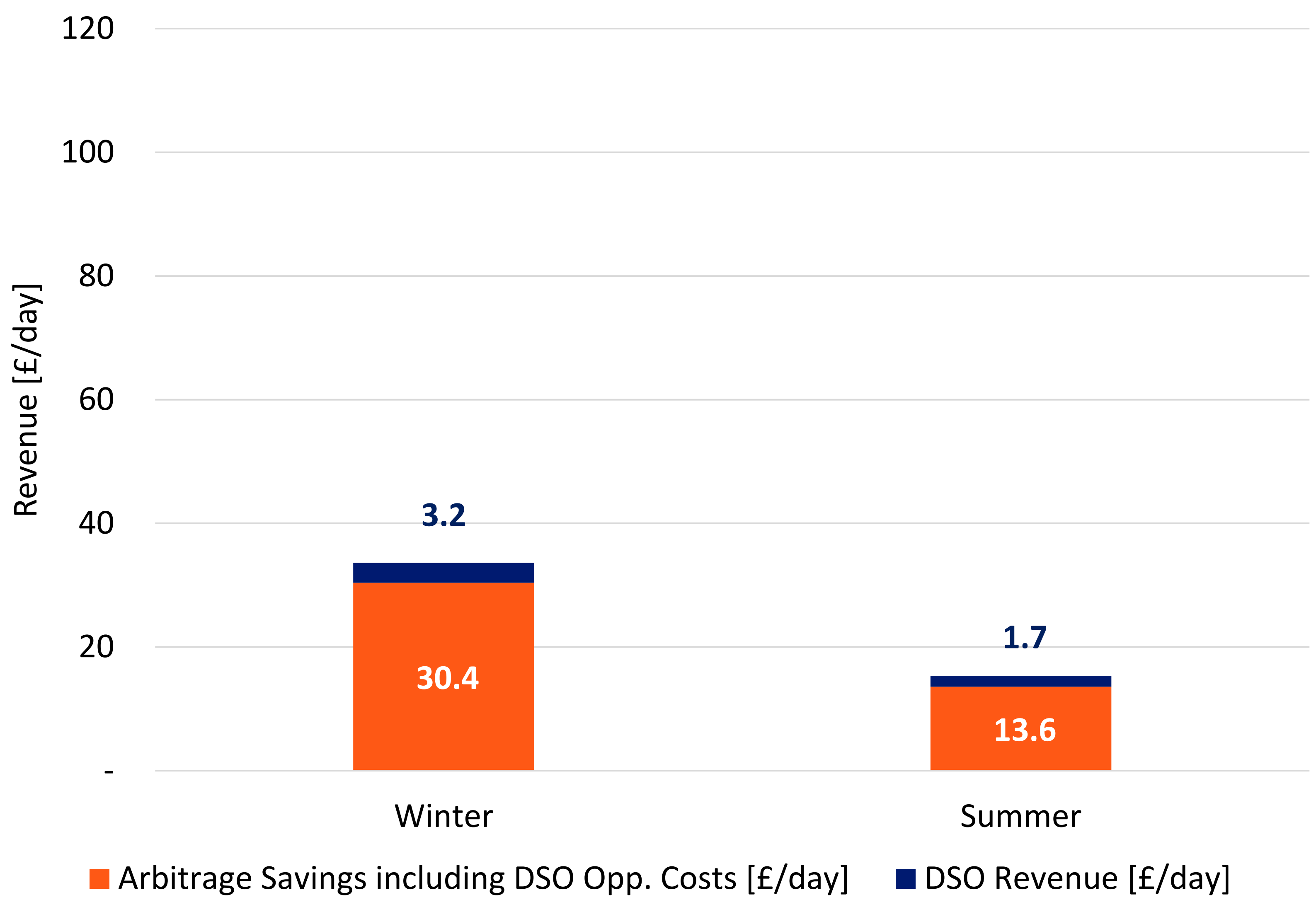
Evolution of the energy flexibility profile for a typical day in Summer (MWh)



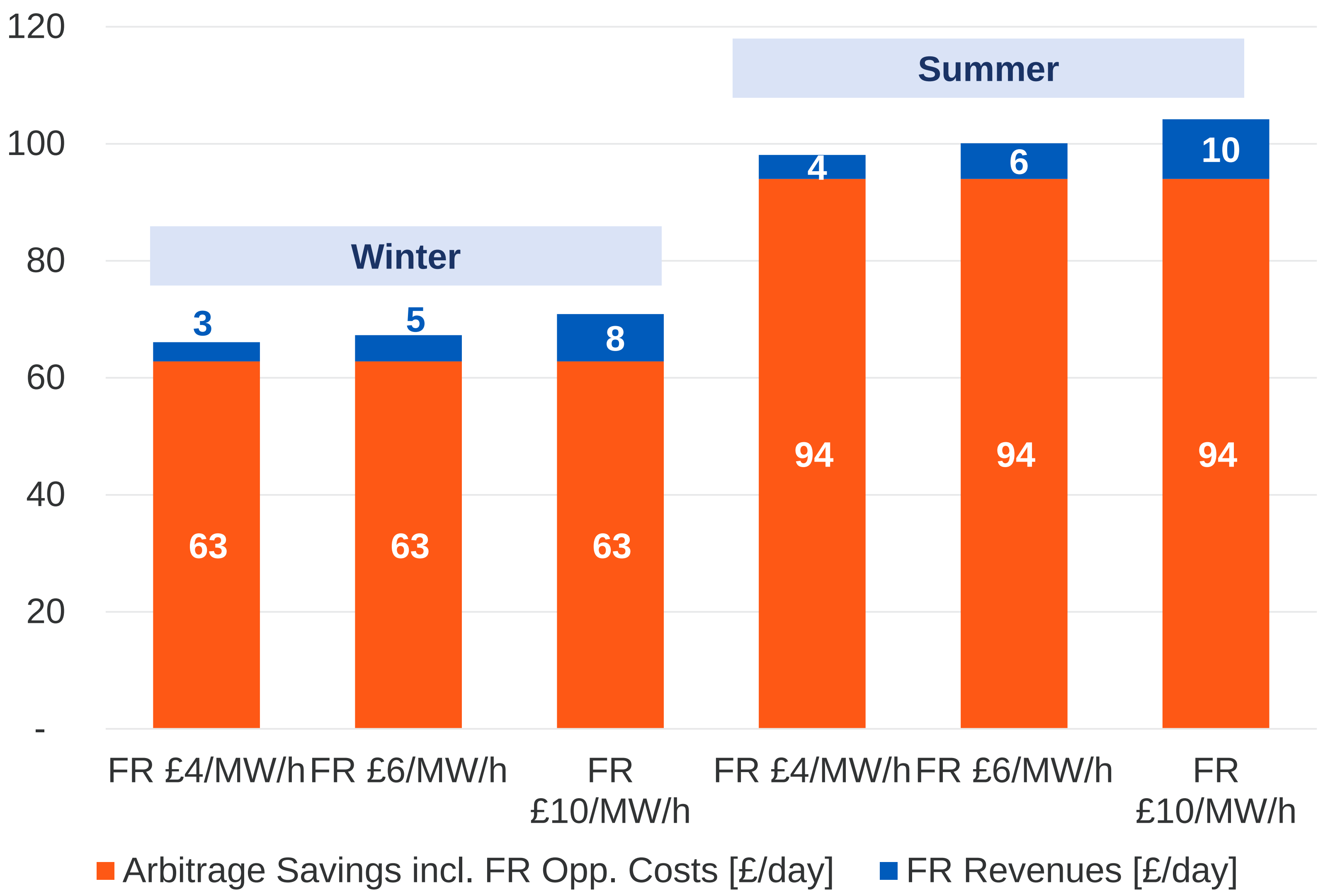
- Case 4, as shown in the previous slide, is characterised by an increased volume of flexibility and mainly because of the addition of a battery. This way, the results demonstrate that the increased power capacity leads to higher revenues.
- **Moreover, in this scenario too, the change in energy is indeed being constrained by the limited availability of downwards energy flexibility both in Winter and Summer, and also being constrained by limited volume of upwards energy flexibility in Summer.**

Results Case 4 – DSO & FR – Economic Benefits

DSO : Daily arbitrage revenue & DSO revenue (£)



FR : Daily arbitrage revenue & FR revenue (£)



- Provision of DSO flexibility services is typically performed **during peak demand conditions** in the distribution network (i.e., between 16h and 20h);
- In contrast, provision of Frequency Response (namely FFR product) is achieved in **pre-defined time windows** and for this case study this was assumed to be during EFA block 2 (i.e., between 03h and 07h);

**Arbitrage revenues include opportunity costs for DSO / resp. FR (see slide below)*

Comments and recommendations

01 Case 4 is the “best case” to maximise revenues

Case 4 (Combined thermal storage + batteries) is the scenario with the greatest volumes of flexibility. This allows for higher volumes of energy and power flexibility, and therefore **higher revenues** (especially in Summer). In the best case scenarios, the hypothetical maximum revenues can go up to:

- £22,400 /MW_{flex}/year for Arbitrage
- £4,200 / MW_{flex}/year for DSO (not including opportunity costs which would reduce significantly the value)
- £22,000 / MW_{flex}/year for FR (not including opportunity costs which would reduce significantly the value)

02 Positive Impact of Energy Storage System on revenues

Higher volumes of energy and power flexibility (see case 3 and 4), and therefore higher revenues are a direct consequence of the presence of an Energy Storage System (ESS) (e.g. residential battery). In comparison with cases without an ESS (cases 1 and 2), the seasonal trend is inverted, with higher revenues in Summer due to lower energy requirements (e.g. heating not required) but also to an increased production from PV plants, that are also complemented by the opportunity that the ESS offers.

Revenue and opportunity cost of DSO Services 03

One of the key observations based on the simulations is that providing DSO flexibility services allows flexibility providers to benefit from additional revenues related with the availability payments for the service. However, this entails an opportunity cost from market arbitrage. In other words, flexibility providers are likely to face higher electricity costs when providing DSO flexibility services.

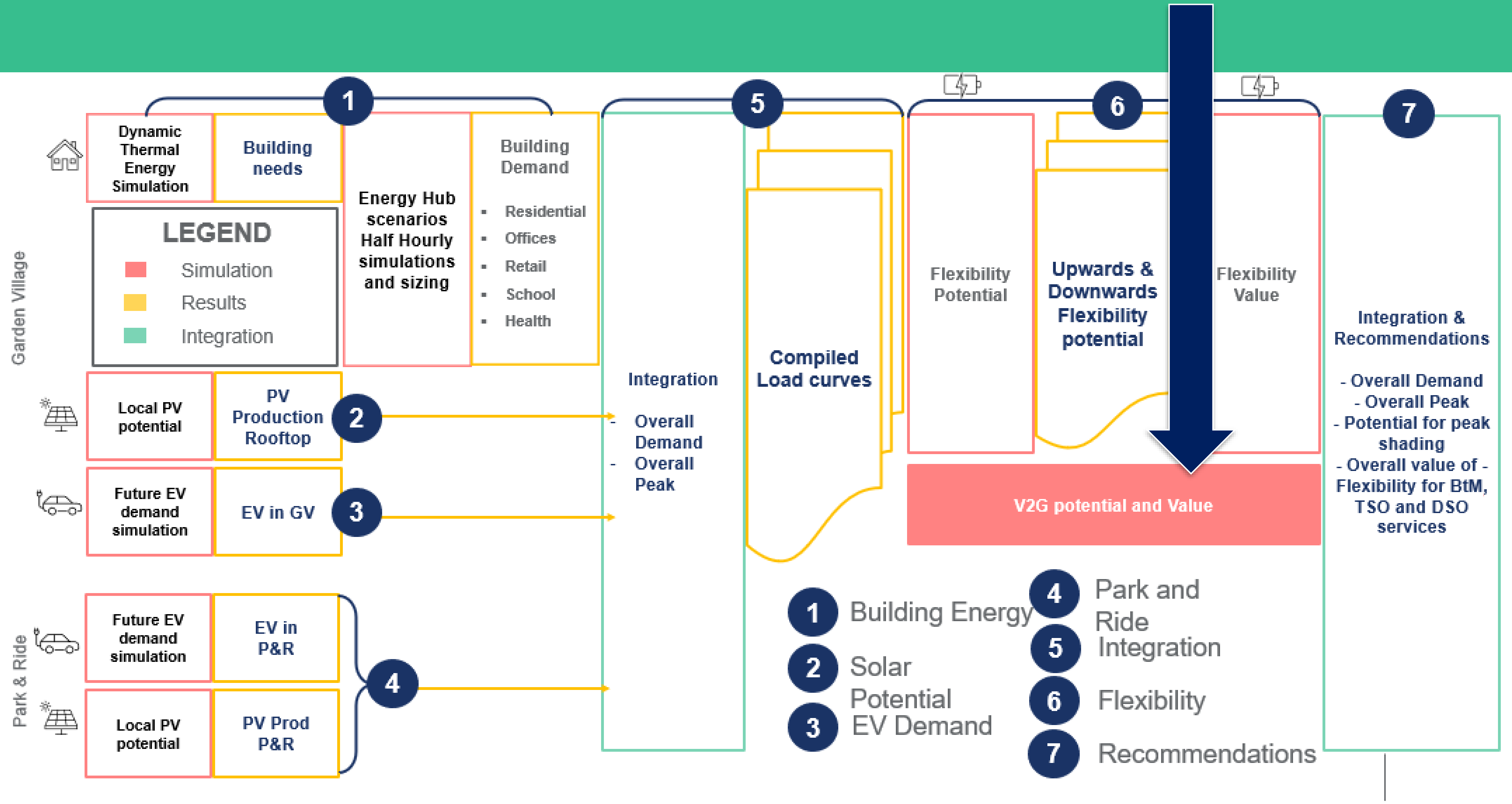
Revenue and opportunity cost of Frequency Response 04

Similar results to those of DSO Services can be observed for Frequency Response, with the difference being that Frequency Response entails a lower opportunity cost.

Frequency Response versus DSO services 05

The results of the simulations highlight that providing Frequency Response and seizing arbitrage opportunities in the wholesale market have higher synergies in terms of economic benefits than providing DSO services combined with seizing arbitrage opportunities. Frequency Response with daily arbitrage should consequently be preferred over DSO Service with daily arbitrage when making final flexibility choices for Salt Cross Garden Village.

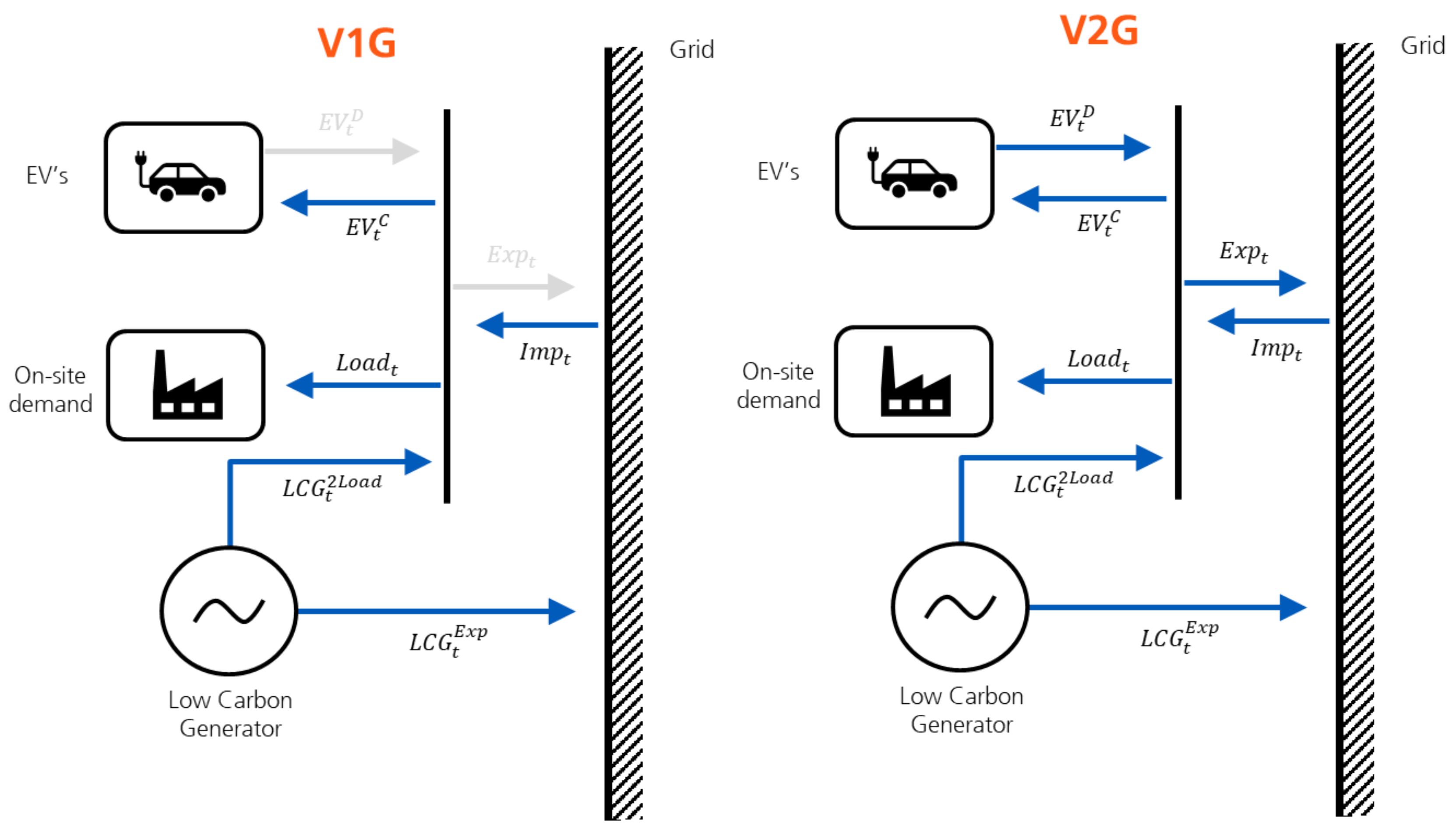
6.3 Flexibility
V1G-V2G



The Grid Energy Management Tool for V1G/V2G

To complement the previous section estimating the residential value, an estimation of the **potential revenues from Smart charging (V1G) and Vehicle to Grid (V2G)** follows. The pool of electric vehicles represented by the future development of Salt Cross Garden Village allows access to a significant aggregated storage capacity which can be managed to drive various strategies of flexibility and lead to economic benefits through various services.

The Grid Energy Management - EV tool is an optimization tool / model to evaluate the revenue streams for EVs providing grid services and operating on merchant markets. The tool is built on the same core functionalities already used as one of the module of EDF's virtual powerplant.



V1G/V2G - Revenues / Costs Modelling

Baseline

"Baseline" charging strategy considers the energy cost associated with battery charging actions once the EV is connected to the grid. Costs are composed by:

- Day-Ahead market prices
- DUoS
- BSUoS
- TNUoS / TRIADS

V1G

"V1G" charging strategy differs from "Baseline" by selecting the optimum market conditions for battery charging actions. Comparatively to Baseline, V1G determines the costs savings composed by:

- Day-Ahead market prices
- DUoS
- BSUoS
- TNUoS / TRIADS

V2G

"V2G" charging strategy considers the potential energy arbitrage opportunities by charging / discharging actions, while respecting energy requirements for mobility purposes:

- Day-Ahead market prices
- DUoS
- BSUoS
- TNUoS / TRIADS

V2G + FR / DSO

"V2G + FR / DSO" charging strategy further explores the value of flexibility of V2G by considering provision of Frequency Response or DSO services. Costs / Revenues streams are composed by:

- Day-Ahead market prices
- Frequency response availability fees
- DSO services
- DUoS
- BSUoS
- TNUoS / TRIADS

V1G/V2G – Reminder of EV cases

EV Scenario	EV penetration	Rapid charging (50KW)	Residential Chargers (%)			Employment Chargers (%)			Education Chargers (%)		
			7kW	22kW	50kW	7kW	22kW	50kW	7kW	22kW	
Case 3	38%	✓	75 %	15 %	10 %	35 %	55 %	10 %	35 %	55 %	10 %

Focus on case 3 of the EV scenarios are highlighted here as they represent the main opportunity for V1G and V2G.

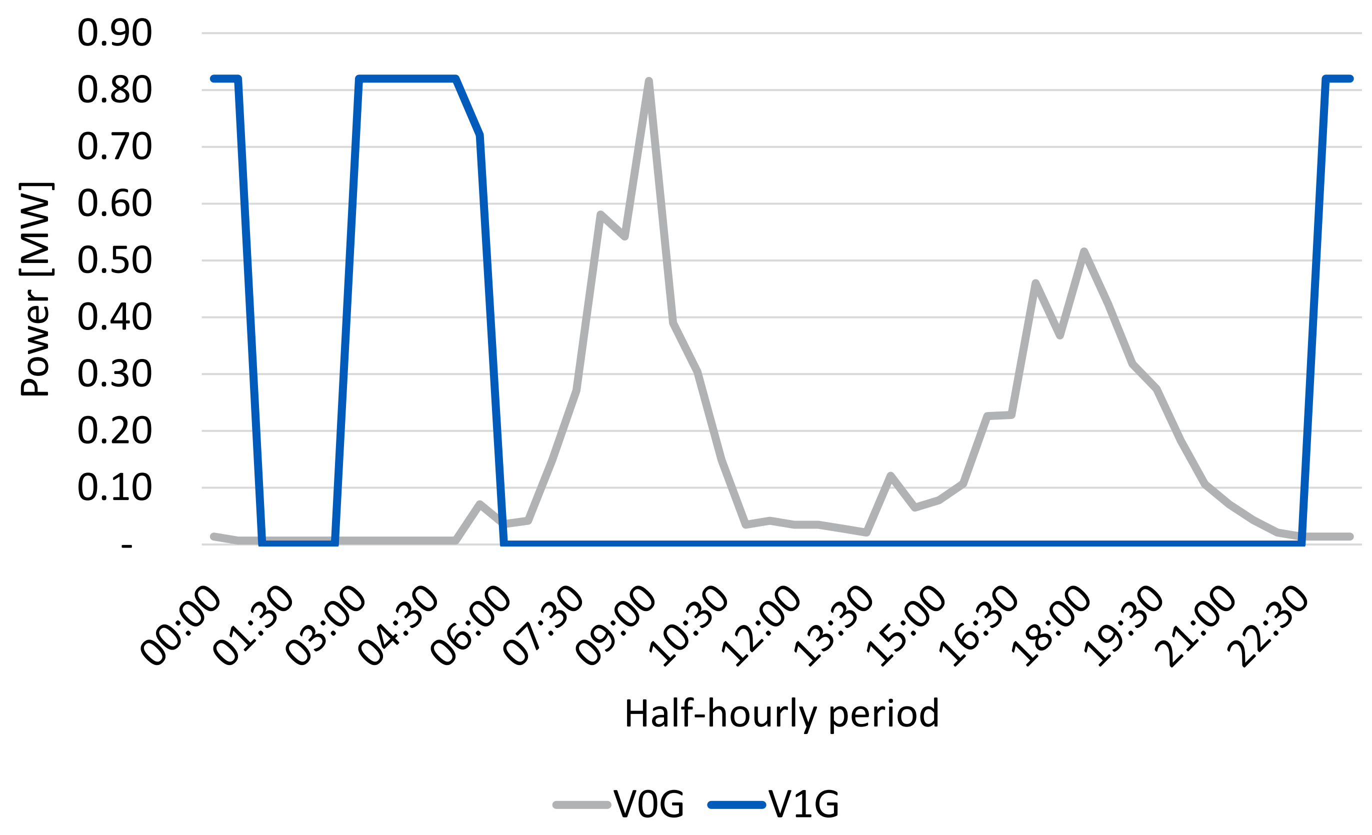
Results: Case 3 | V1G Optimised Charging Profiles

Case 3

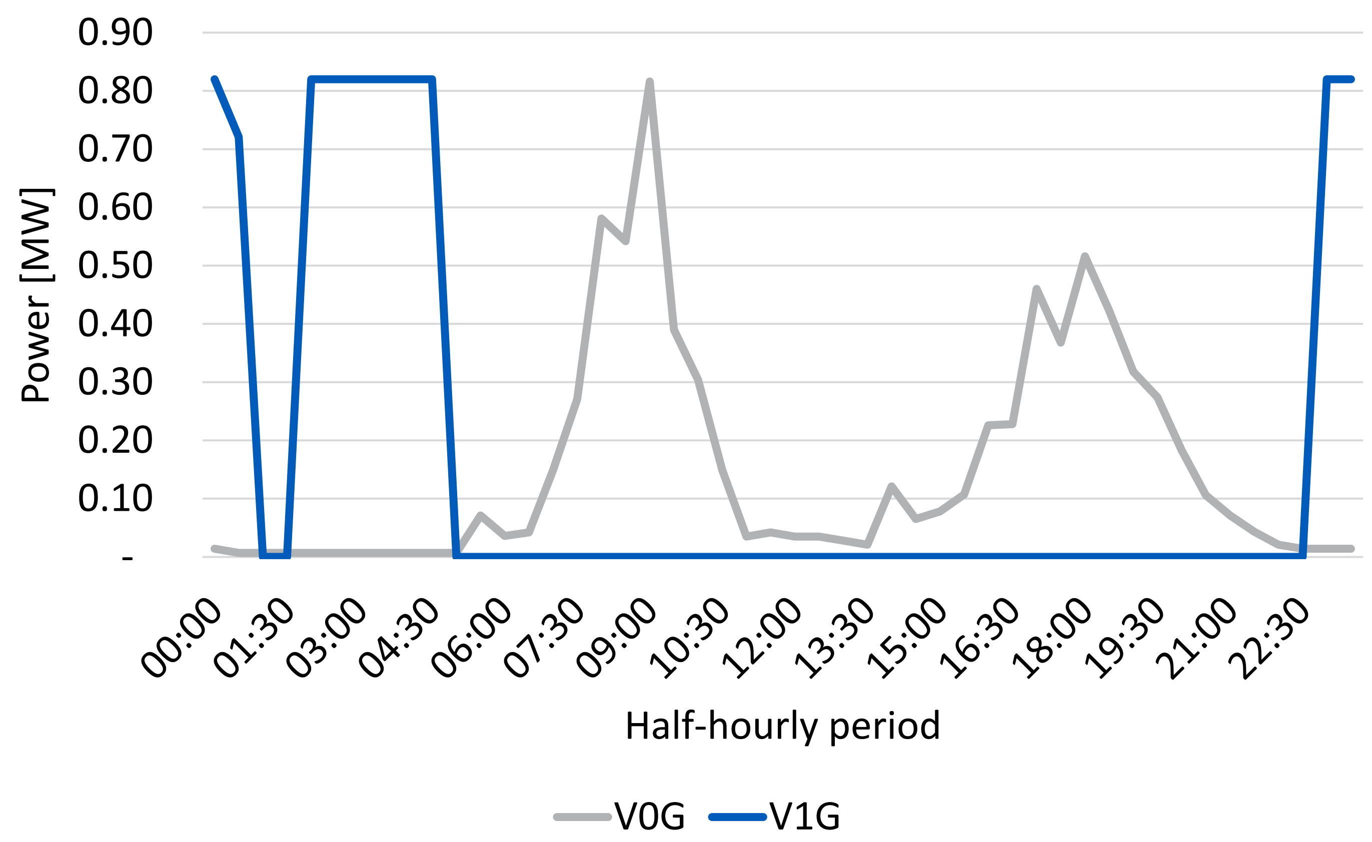
38%
EV penetration

Rapid charging (50kW)

Comparison of power consumption profile with and without Smart Charging (V1G) for a typical day in Winter (MW)



Comparison of power consumption profile with and without Smart Charging (V1G) for a typical day in Summer (MW)



- Similar to Case 1 and 2, the results show no significant changes in optimum charging profiles between Summer and Winter market conditions for V1G strategies.
- **Case 3 is exhibiting the highest peak in consumption (i.e., 0.8 MW) due to the high EV penetration (38%) and due to the existence of 50kW chargers.**
- The dip around 1:30am can be explained by a slightly higher price, resulting in no smart charging during this time.

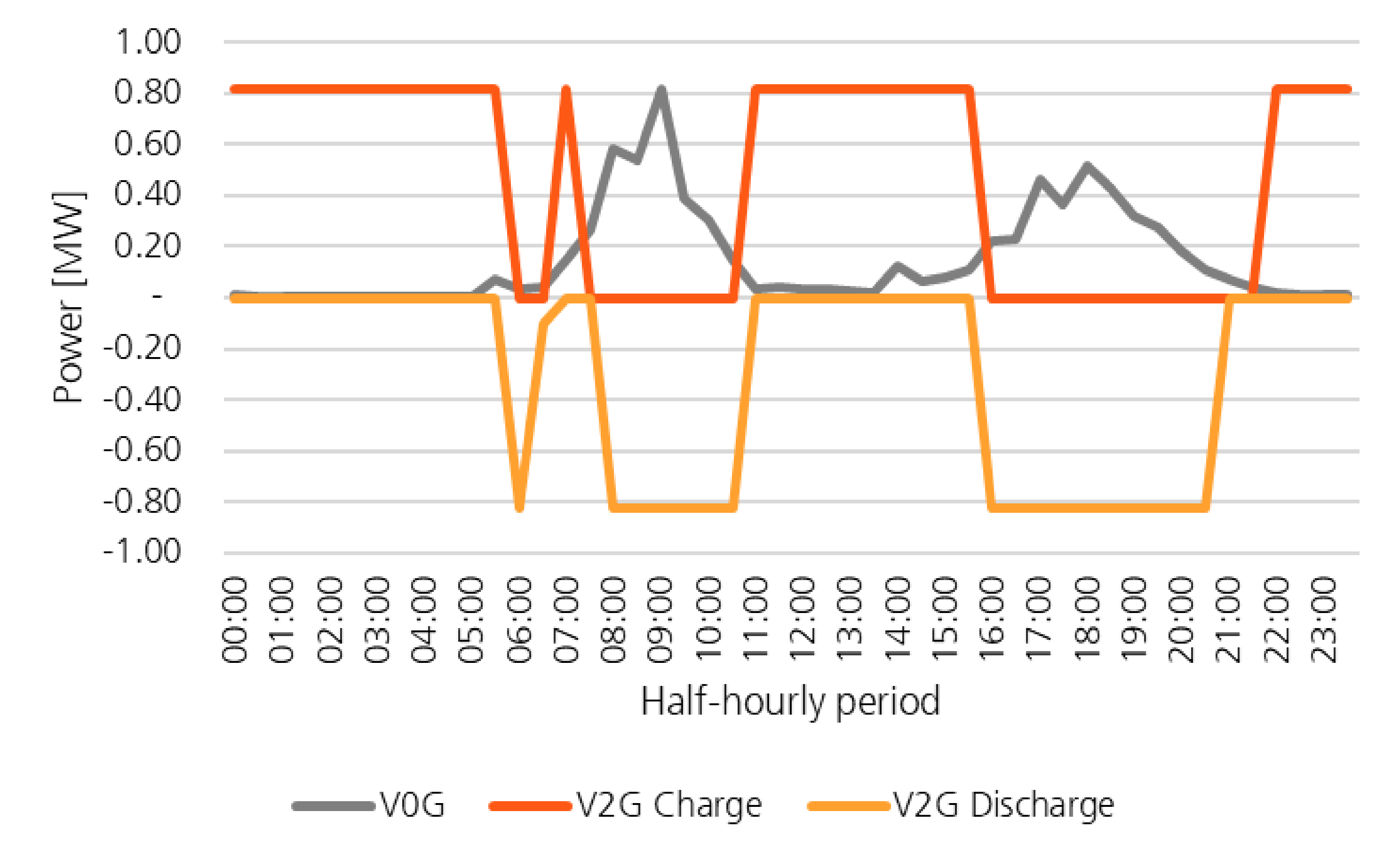
Results: Case 3 | V2G Optimised Charging Profiles

Case 3

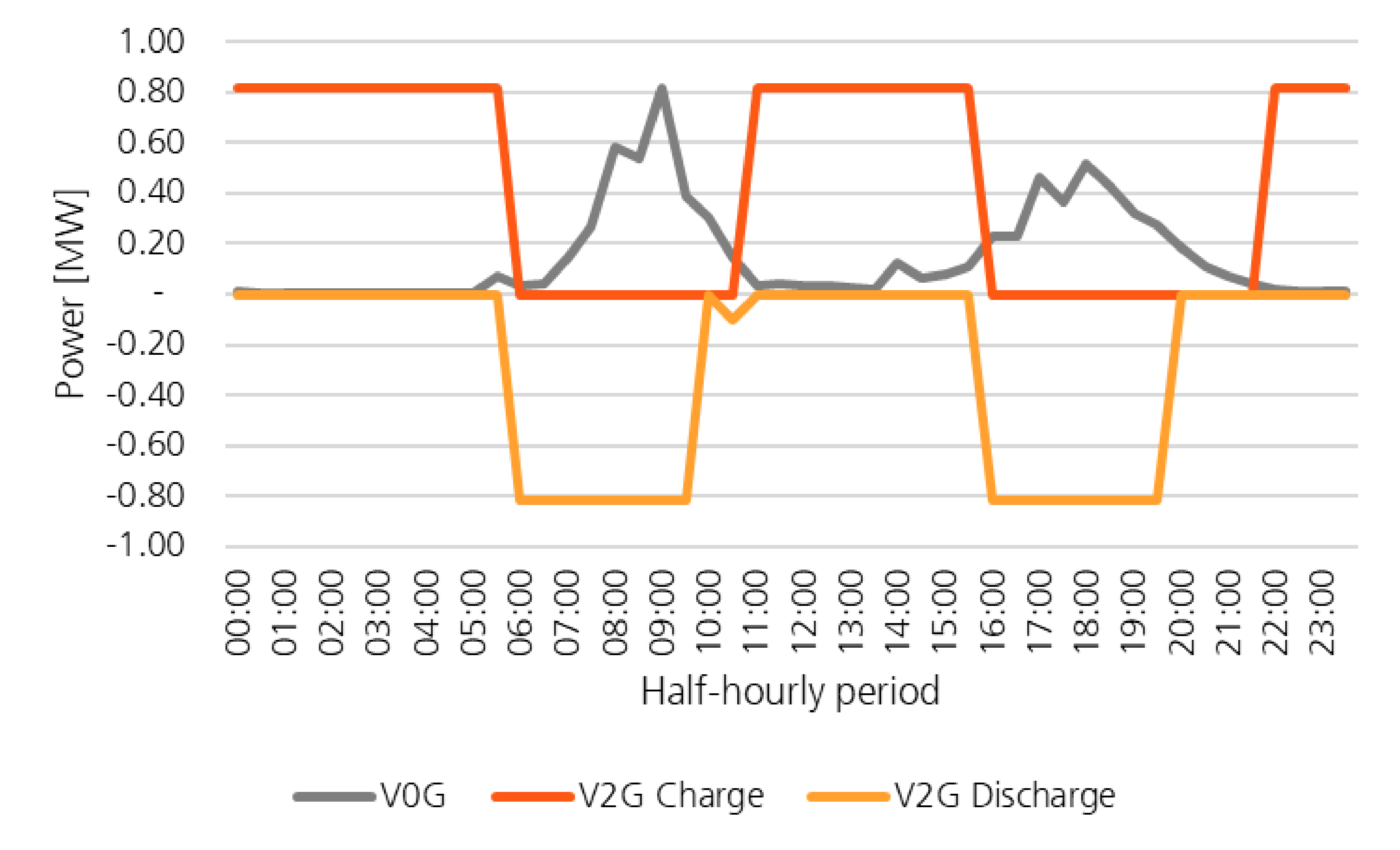
38%
EV penetration

Rapid charging (50kW)

Comparison of power consumption profile with and without V2G for a typical day in Winter (MW)



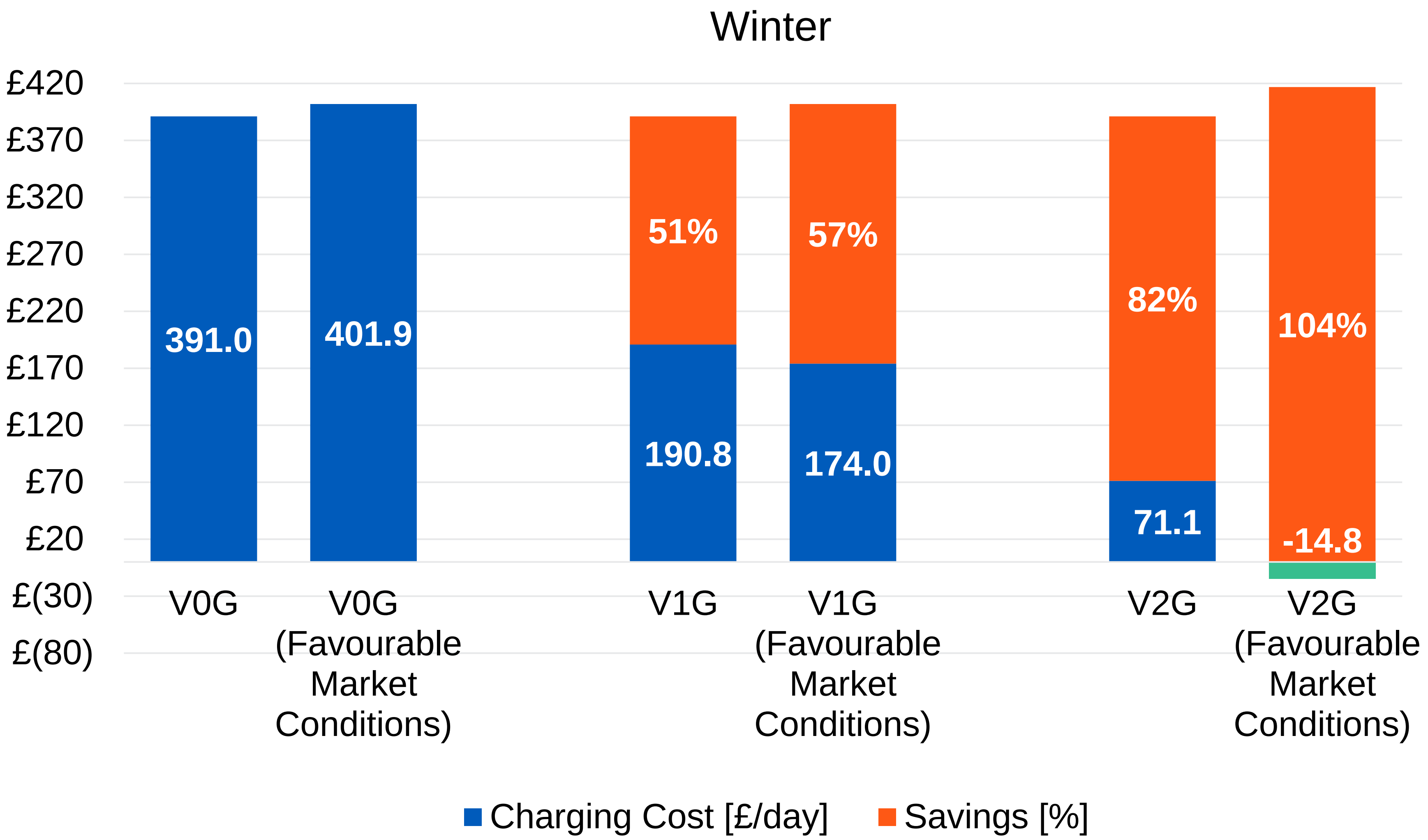
Comparison of power consumption profile with and without V2G for a typical day in Summer (MW)

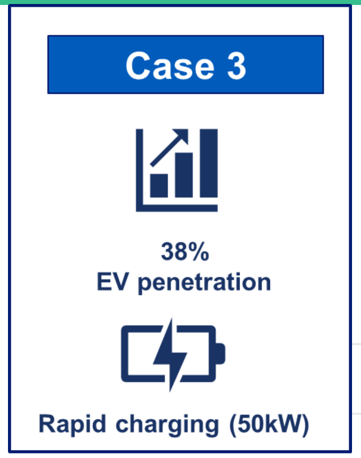


- Similar to Case 1 and 2, a higher number of charge/discharge cycles can be expected in Winter when compared to Summer market conditions.

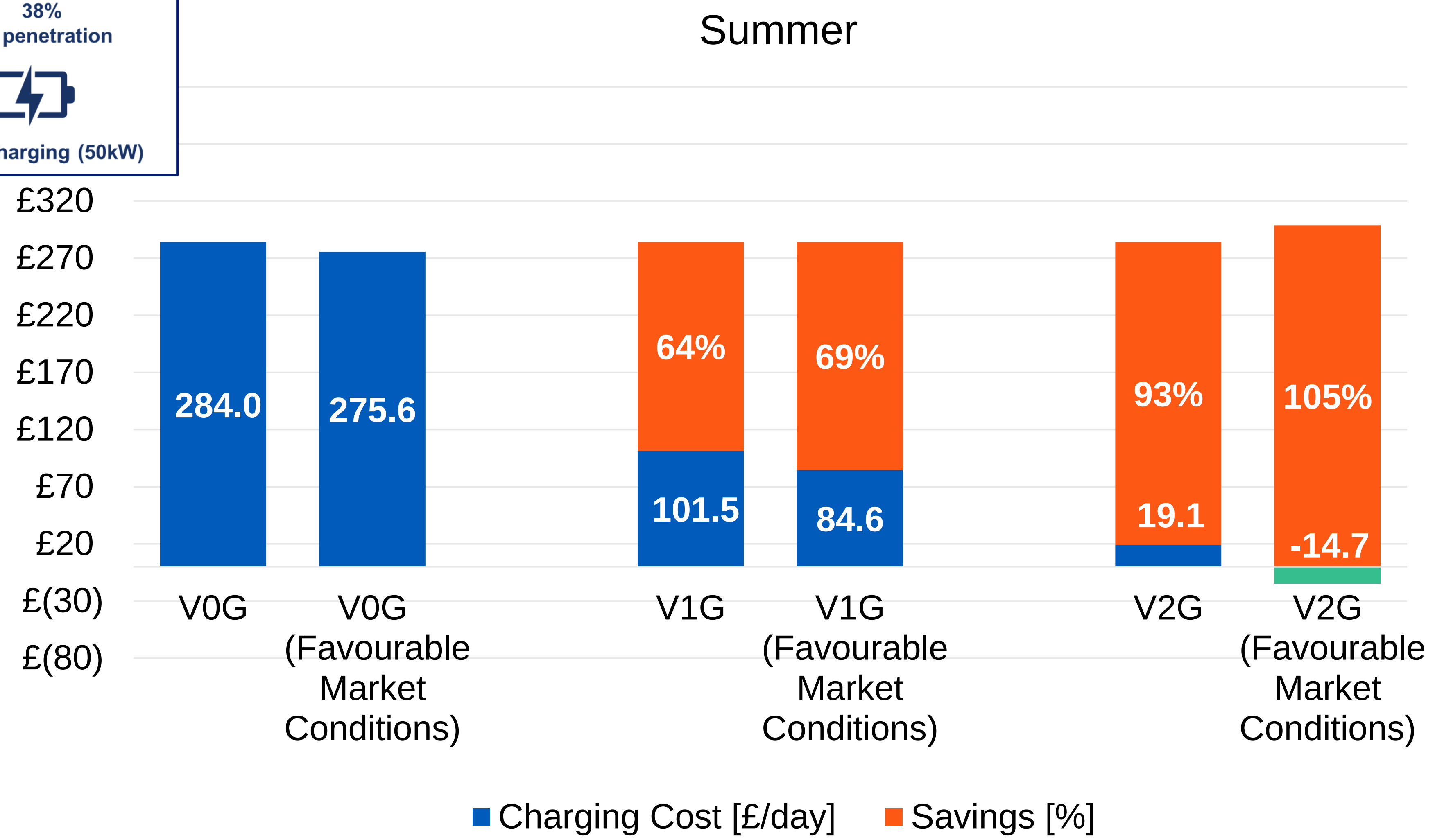
Results: Case 3 | Economic Benefits

Economic benefits for a typical day in Winter
(£ for costs and £/day for savings)





Economic benefits for a typical day in Summer
(£ for costs and £/day for savings)



- **The reduction in charging costs, for Case 3, exhibit the highest reduction of all cases :**
  - Up to 57% and 104% reduction, respectively for V1G and V2G in Winter
  - Up to 69% and 105% reduction, respectively for V1G and V2G in Summer
  - Both in Summer and Winter and in favourable market condition, V2G allow a revenue of ca. £14/day
- **This is due to a combination of factors:**
  - **High EV penetration (38%) associated with the existence of 50kW chargers – which allow for enhanced arbitrage opportunities.**

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Comments and recommendations

01

Setting up V1G and V2G strategies is key to making cost savings

V1G charging strategies can potentially reduce charging costs by up to 57% in Winter, and up to 69% in Summer. Full recovery of the charging costs can be achieved with V2G charging strategies, bringing additional revenues of ca. £14/day.

02

V2G is more sensitive to seasonality than V1G

Although market conditions differ between Summer and Winter periods, V1G charging profiles remain similar. In contrast, when considering V2G charging strategies, Winter market conditions result in a higher number of charge/discharge cycles comparatively to Summer periods.

03

Provision of flexibility services can enhance economic attractivity of V2G…

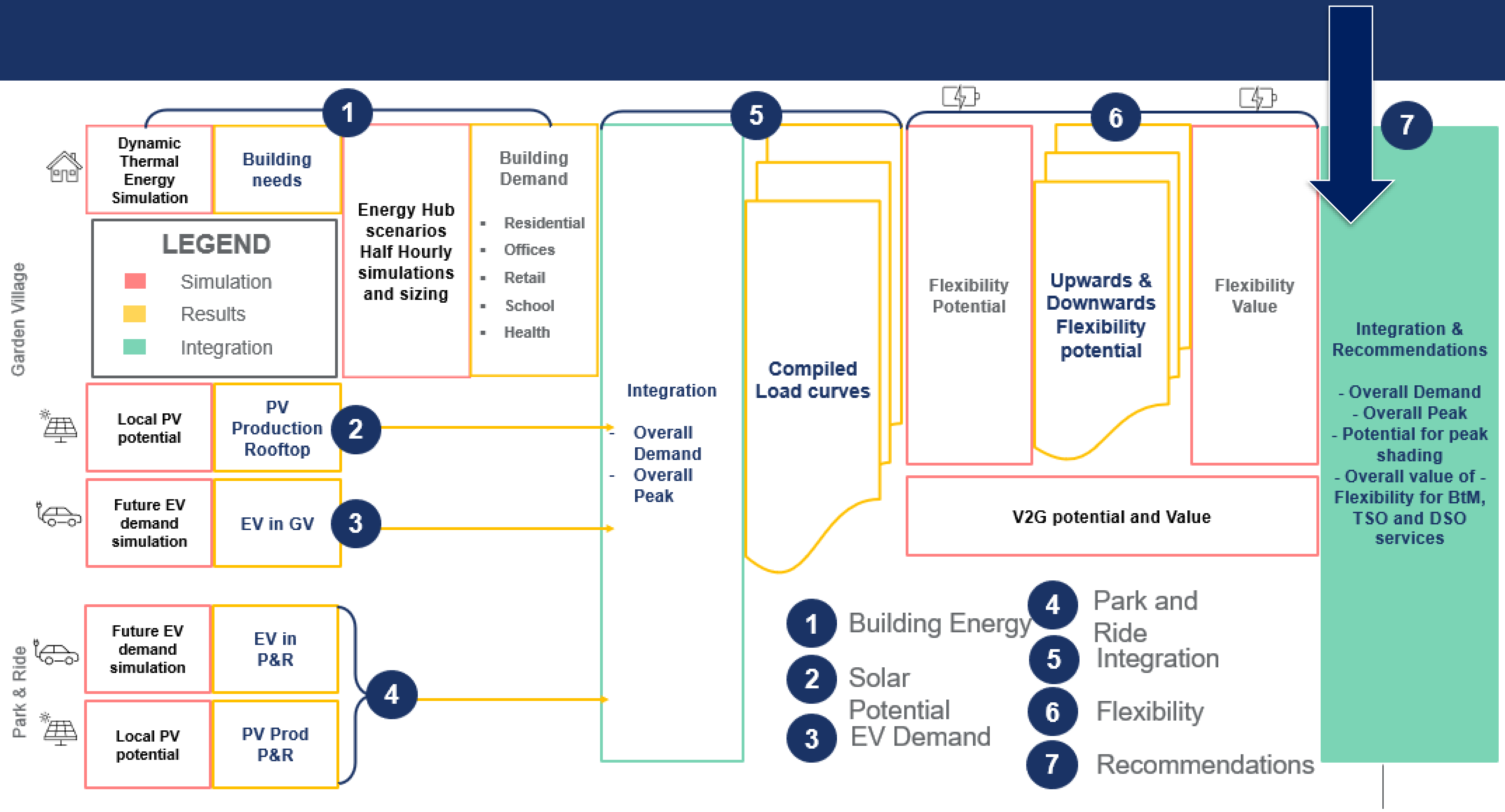
Provision of flexibility services, i.e., Frequency Response or DSO services, can support the business case for V2G with an additional revenue stream, although this may decrease energy arbitrage opportunities and thus increase cost associated with charging actions. Trade-off between the two services was observed.

04

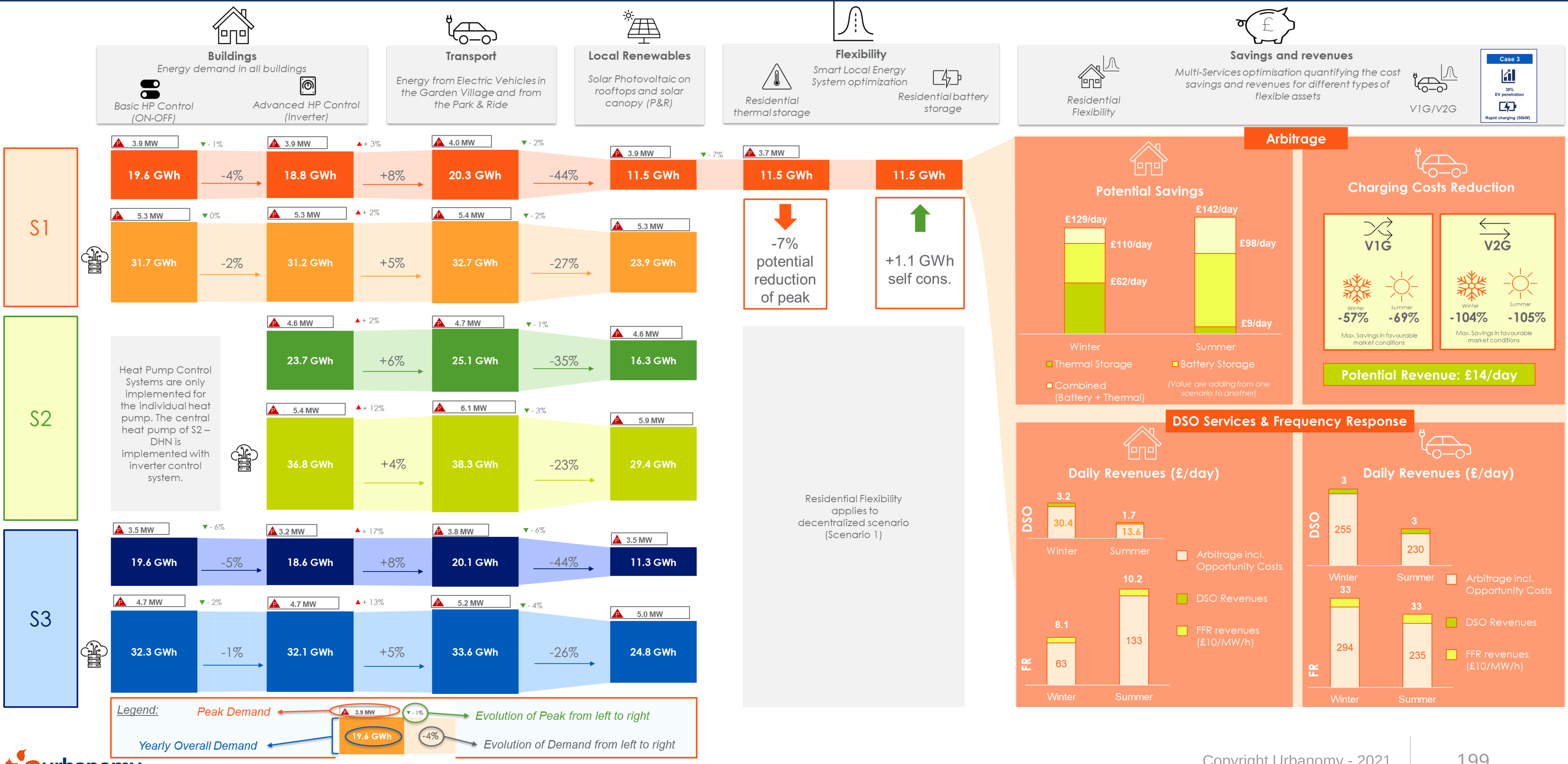
… however, it may have a stronger impact on battery degradation

Increased number of charge/discharge cycles with V2G charging strategies may be detrimental for battery degradation. Battery degradation (i.e. limited number of cycles) not considered in preliminary studies but may be required in further analysis.

7. Overall integration and Key recommendations



Salt Cross Garden Village study: Results Overview



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Reaching NZ is possible through:

High Fabric efficiency to keep space heating below <15kwh/m2/y.

Efficient lighting and appliances as the share of non-thermal needs will become significant in high standard fabric buildings. Smart home monitoring systems can contribute.

Increasing PV generation and/or exploring link with other local renewables generation sites.

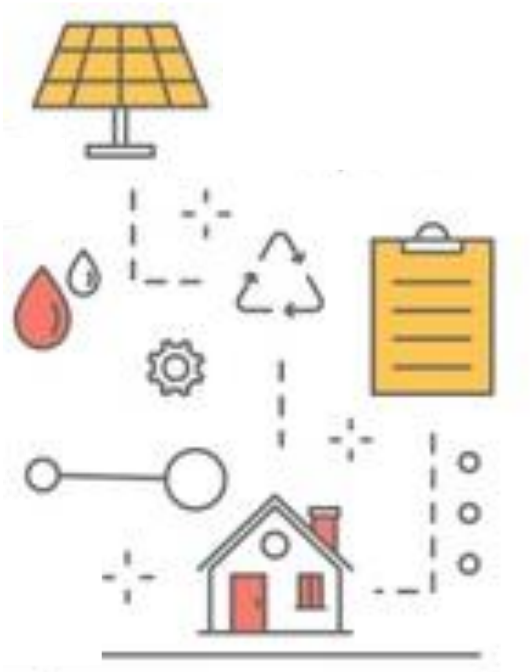
Efficient heat pump systems with advanced control to keep low energy demand for thermal needs.

Integrating urban design and choice of typologies within the development of the energy system to ensure optimised efficiency and operation.

Good building design including solar shading to avoid cooling needs in summer.

V1G and V2G allowing to shift the peak and reduce largely the charging costs for EV.

Heat recovery from computing, focused on specialist office rather than on adding a large scale data centre



Use flexibility from building and transport assets that allow to reduce peak demand and increase self consumption.

Storage Combining low potential of thermal flexibility with **residential batteries** to increase revenues.

Office Cooling When required (specialist offices), **active cooling in summer and passive cooling in winter** allows to reinject heat in the borehole system and keep it efficient on the long run.

Combining various heat sources with the right seasonal variability: solar thermal, geothermal, waste water recovery, waste heat recovery, …

Ambient loop systems considering potentially several smaller networks.

Geothermal borehole system bringing renewable source of heat that can be used also as a seasonal storage in the condition of being able to reinject heat during the summer. Requires additional geological study.

Focusing on arbitrage revenues mainly as some other services have a significant opportunity cost.

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We would be happy to exchange further.
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Thank you!

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