ENERGY LOCAL STORAGE ADVANCED SYSTEM

# Introduction to the ELSA pilots & use cases

Stakeholder Workshop, Aachen

2nd & 3rd May 2016

Vincenzo Croce, Engineering

# ELSA Main objectives

- Combine **2nd life batteries** with an innovative local ICT-based energy management system in order to develop a low-cost, scalable and easy-to-deploy battery energy storage system.
- Develop innovative service-oriented business models.
- Manage sustainability and social acceptance through comprehensive life-cycle and socio-economic impact assessments

# ELSA Pilot Sites

- 6 test sites to cover all the relevant applications for distributed storage installed at LV level, ranging office building, industrial site, solar energy generation, DSO and a university R&D centre

- 3 test sites representing Districts
  - Kempten, Aachen, Terni
- 2 test sites representing Buildings
  - Gateshed College, Ampere Building
- 1 test site representing a Factory
  - Nissan farm in Barcellona

# ELSA Pilot Sites (2)

- E.ON Energy Research Center
  - A district represented by the multi-disciplinary research institution of RWTH Aachen University. Three buildings and a small Wind turbine will be equipped with a battery to optimize the power consumption.

- ASM Terni
  - A district with buildings and a battery energy storage deployed along the Low Voltage branch of its owned smart grid to mitigate and smooth the fluctuating power output generated by the nearby PV farm.

- Germany, City of Kempten
  - A residential district of 6 buildings which consist of 81 flats. Will be equipped with roof top PV plants, mixing prosumers and consumers, and a battery system for flexibility aimed at maximize the district auto-consumption.

# ELSA Pilot Sites (3)

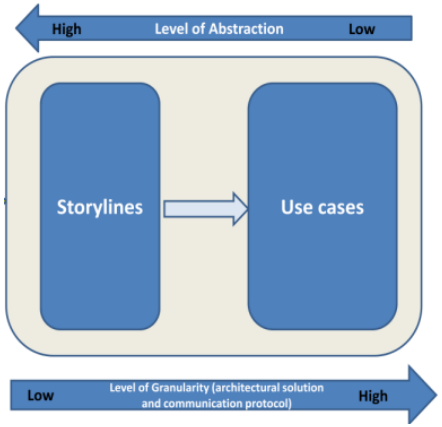
- Gateshead College
  - A building which will be provided with a battery system to optimise the electricity grid locally but also to develop a training package to support the wider deployment of distributed storage.

- Ampere Building at La Defense, Paris
  - A building situated in the most important business area of Paris. ELSA will provide a storage solution able to satisfy the most stringent safety and security specifications in critical office environment.

- Nissan Barcellona Plant
  - A large manufacturing plant will be provided with a battery system and be integrated with PV panels in order to optimise the energy consumption for lighting.

# ELSA Storylines and Use Cases

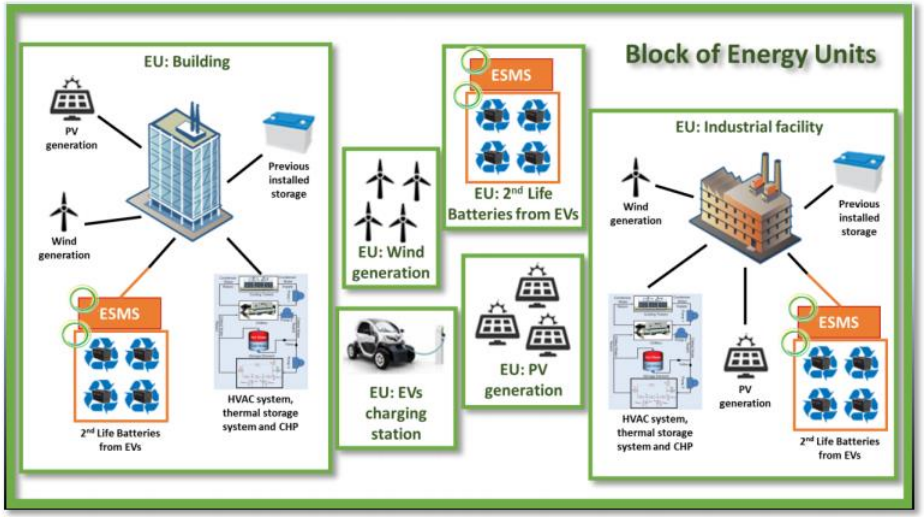
- Storyline
  - Describes a general requirement, idea or concept independently from a specific technical realization such as an architectural solution. Storylines can be seen as High Level Use Cases that constitute the starting point for use cases definition.
- Use case
  - which describes in details the specific ELSA functionality and the set of possible sequences of interactions between ELSA systems and one or more actors in a particular environment and in relation to a specific goal.



# ELSA Block of Energy Unit and District

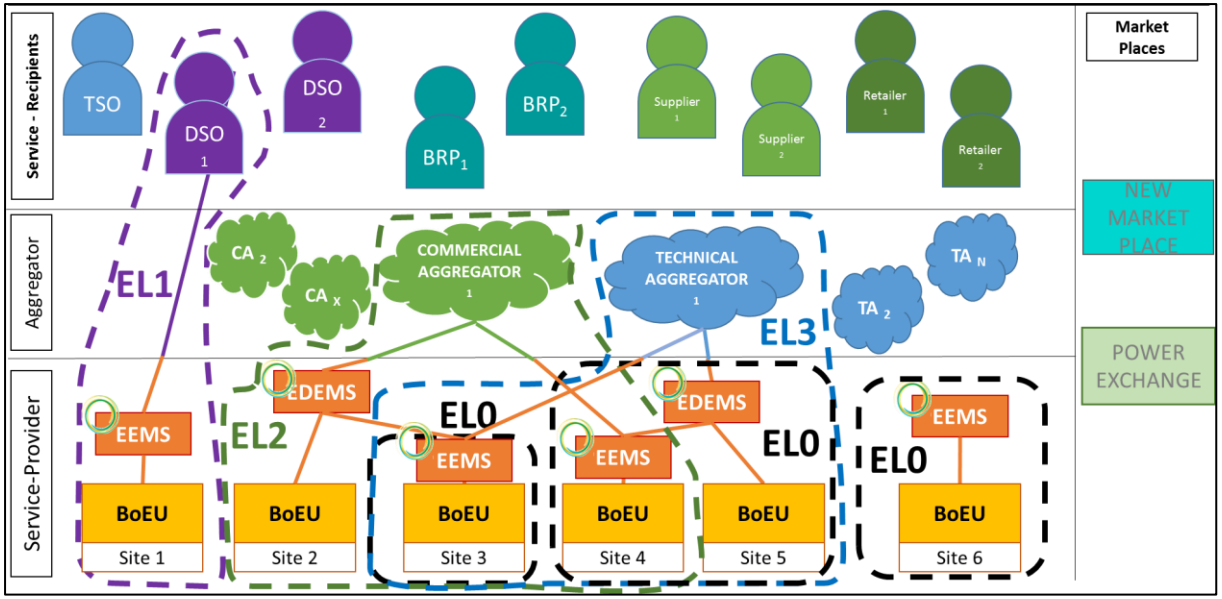
- Block of Energy Unit
  - set a energy units, strongly connected each other, with a unique management system for the different resources of the energy units belonging to the block.

- District
  - the grouping of many blocks.
  - has a general goal of coordinating the different blocks to offer aggregated resources.



# ELSA Storylines

- Storylines:
  - EL0 – ELSA Block of energy units operating autonomously
  - EL1 – ELSA Block of Energy Units – DSO
  - EL2 - ELSA District – Commercial Aggregator
  - EL3 – ELSA District – Technical Aggregator



# ELSA Services and Use Cases

| ELSA Services | Use case |
|---|---|
| Peak shaving | • Peak shaving for power subscription cost optimization |
| Demand Response | • Auto consumption<br>• CO2 minimization<br>• Cost minimization<br>• Flexibility<br>• Balance group optimization<br>• Participation to the energy trade market |
| Ancillary Services | • Primary reserve<br>• Dynamic reactive Power control<br>• Reactive Power Compensation |
| Power quality | • Harmonic Filtering<br>• Power balance |
| PV Power smoothing | • Request the PV Power smoothing service<br>• Delivery of PV Power smoothing service |
| Energy Purchase Time Shifting | • Energy Purchase Time Shifting |

# Pilots - Storylines – Use Cases – services

| Test site | Storyline EL0 | | | Storyline EL1 |
|---|---|---|---|---|
| **City of Terni, Italy** | - | | | Power quality |
| | - | - | | Use case: Power balance |
| | | | | Ancillary Services |
| | | | | Use case: Primary reserve<br>Use case: Dynamic reactive Power control<br>Use case: Reactive Power Compensation |
| **Ampere Building,** | - | | | |
| | | | | - |
| **Nissan Factory Barcelona,** | Peak shaving | Energy Purchase Time Shifting (Arbitrage) | PV Power smoothing | |
| | Use case: Peak shaving for power subscription cost optimization | Use case: Energy Purchase Time Shifting | Use case: PV self-consumption maximization by power smoothing | |
| **E.ON Energy Research Center,** | Demand Response | | | |
| | Use case: $CO_2$ minimization<br>Use case: Auto Consumption | | | |
| **City of Kempten,** | Demand response | PV-power smoothing | | |
| | Use case: Auto Consumption | Use case: PV self-consumption maximization by power smoothing | | |
| **SASMI Building, Gateshead College,** | Peak Shaving | Demand response | Energy Purchase Time Shifting (Arbitrage) | |
| | Use case: Peak shaving for power subscription cost optimization | Use case: Auto Consumption | Use case: Energy Purchase Time Shifting | |

# Pilots - Storylines – Use Cases – services

| Test site | Storyline EL2 | Storyline EL3 |
|---|---|---|
| **City of Terni,** | - | Peak shaving |
| | - | Use case: Peak Shaving consumption to re-duce peak loads in peak hours |
| | | PV Power smoothing |
| | | Use cases:<br>Request the PV Power smoothing service<br>Delivery of PV Power smoothing service |
| **Ampere Building,** | - | - |
| | - | - |
| **Nissan Factory Barcelona,** | | |
| | | |
| **E.ON Energy Research Center,** | Demand Response | Demand Response |
| | Use case: Cost minimization | Use case: Flexibility |
| **City of Kempten,** | Demand Response | Ancillary Services |
| | Use case: Balance group optimization<br>Use case: Participation to the energy trade market | Use case: Primary reserve<br>Use case: Reactive power compensation |
| **SASMI Building, Gateshead College,** | Demand response | Demand response |
| | Use case: Cost minimization | Use case: Flexibility |

ENERGY LOCAL STORAGE ADVANCED SYSTEM

# Flexibility Analysis

Stakeholder Workshop, Aachen

2nd & 3rd May 2016

*Team UTRCI*: Sarah O'Connell and Stefano Riverso

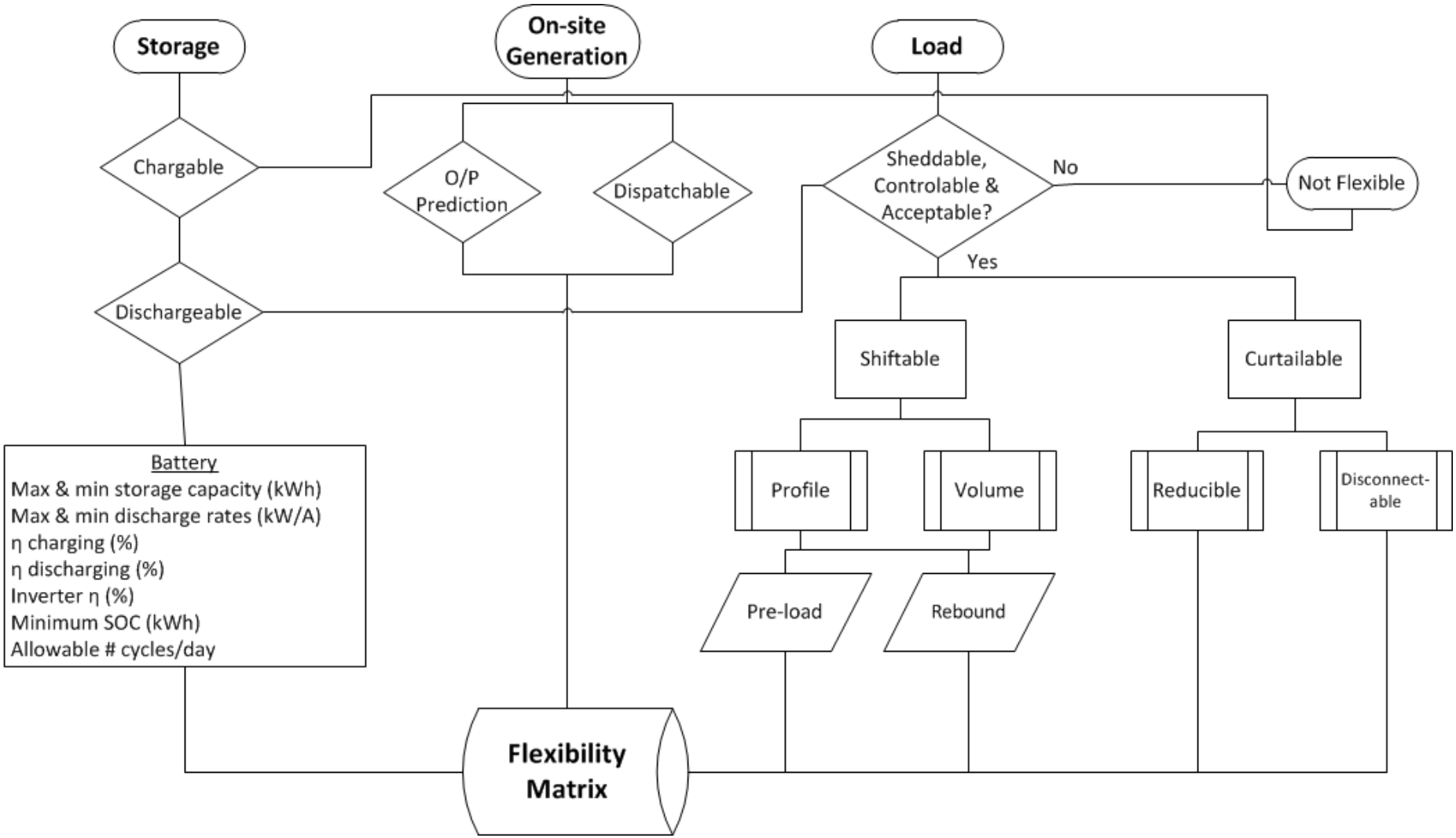
## Developed in ELSA

- Flexibility Assessment Process
  - Flexibility Characterisation
  - KPIs & KPI Label

## Pilot Sites Flexibility Assessment

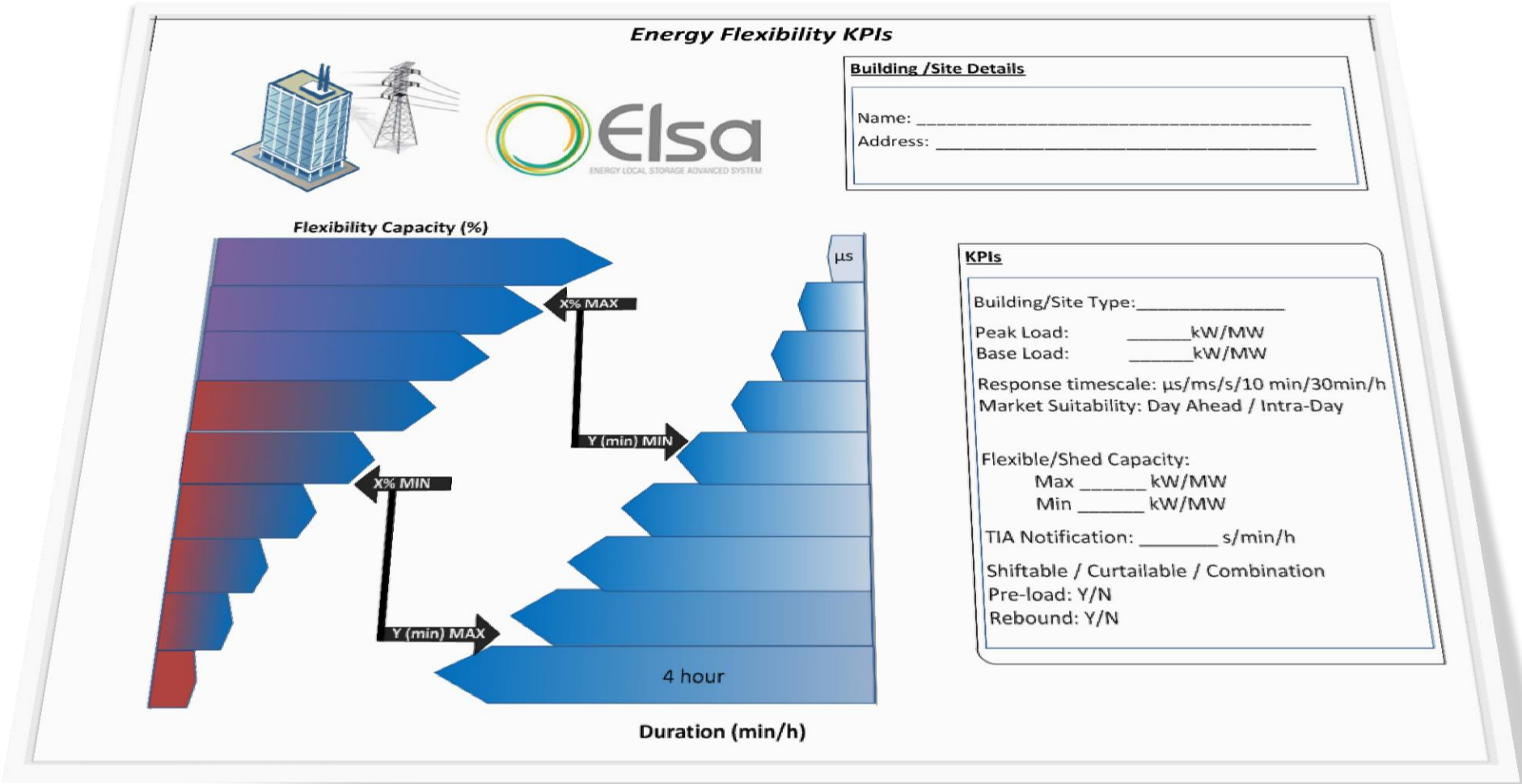
- Energy Audit (ISO 5002:2014) – What is there?
- Flexibility Characterisation – What is flexible?
- Benchmark Comparison – How does it compare?
- KPIs – What are key factors?

# Flexibility Characterisation Process



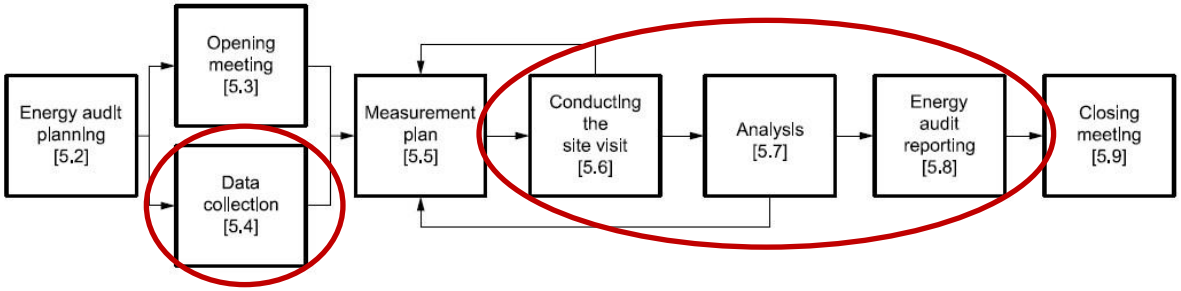

Created from synthesis of Definition, Formulation & Algorithms

# Example Flexibility KPI Label



# Energy Audit ISO 50002

## Adapted for Flexibility




**Energy Audit Process Flow Diagram (ISO 50002:2014)**

**Audit objective:** Determine energy flexibility of a site by identifying and quantifying loads, storage and on-site generation

**Scope:** ELSA project

**Energy & Power Use:** load profiles, peak & base load, load identification e.g. HVAC, Lighting, Electric Vehicles

**Relevant Variables:** Occupancy Schedules, Temperature set points, Equipment set points, Energy pricing & cost structure, Weather data (if available)

**Energy Flexibility Performance Indicators:** KPIs

**Outputs:**

- Systems identification & load characterisation
- Recommended sensor & control improvements, if applicable
- Energy flexibility improvement opportunities, if applicable

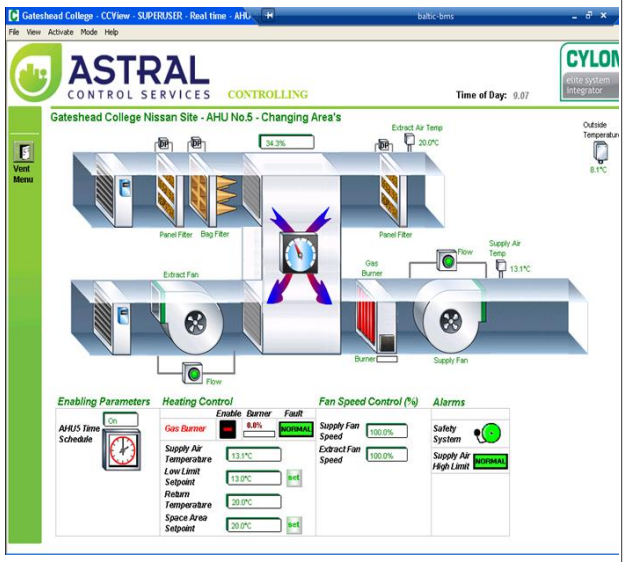
# BEFORE ENERGY AUDIT

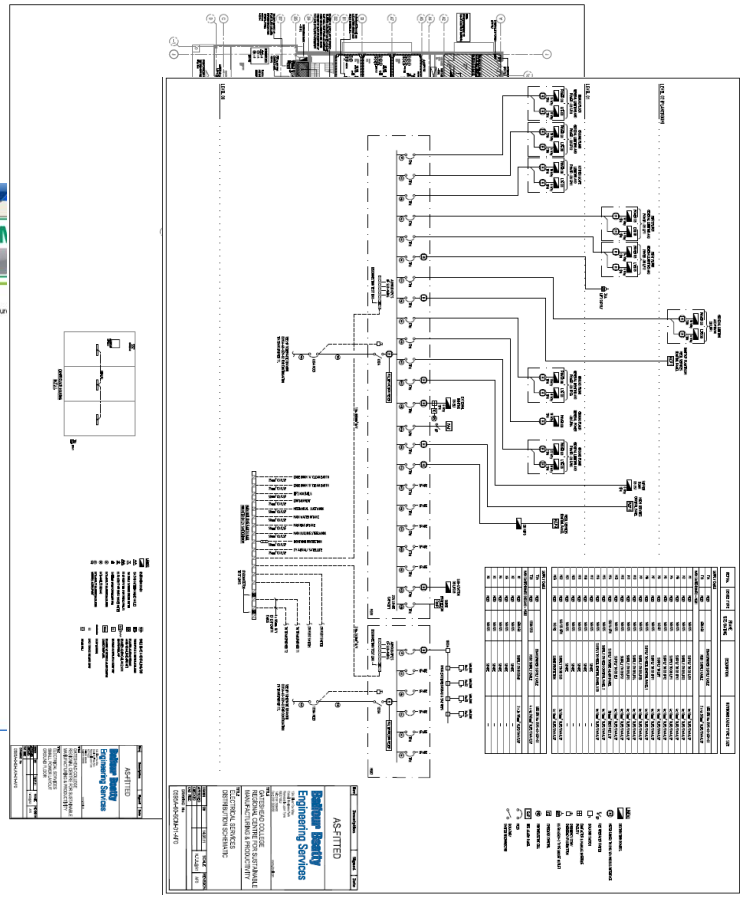
## Pilot Site Example – SASMI Building, Gateshead College

- ~~33~~ (16 x 3) kWh 2nd life batteries (ex 3 x 24kWh Nissan Leaf batteries)
- ~~Electric water heater~~
- 30kWp PV
- Other Loads?

# Energy Audit – Data Collection

- **BMS (SCADA / M&T )**
- **Drawings & Specifications (O&M Manual)**
- **Energy & Power Data**



| M1 Main Incommer | | Lift | | External Li | MCP2 | MCP3 | Server 1 | LP01_L | LP01_P | LP02_L |
|---|---|---|---|---|---|---|---|---|---|---|
| 26/05/1901 00:00 | kW h | kWh | | kWh | kWh | kWh | kWh | kWh | kWh | kWh |
| 29/12/2015 04:00 | 15 | 0.08 | | 0.17 | 0.04 | 0.172 | 1.281 | 1 | 2 | 1 |
| 29/12/2015 05:00 | 17.63 | 0.08 | | 0.16 | 0.04 | 0.16 | 1.281 | 0 | 2 | 0 |
| 29/12/2015 06:00 | 23.25 | 0.09 | | 1.34 | 0.24 | 0.16 | 1.289 | 0 | 1 | 0 |
| 29/12/2015 07:00 | 28.25 | 0.08 | | 1.951 | 0.12 | 0.16 | 1.277 | 1 | 1 | 0 |
| 29/12/2015 08:00 | 29.63 | 0.08 | | 1.949 | 0.22 | 0.148 | 1.293 | 0 | 2 | 0 |
| 29/12/2015 09:00 | 37.13 | 0.09 | | 0.201 | 0.23 | 0.16 | 1.297 | 1 | 1 | 1 |
| 29/12/2015 10:00 | 37.13 | 0.08 | | 0.199 | 0.11 | 0.152 | 1.301 | 0 | 2 | 0 |
| 29/12/2015 11:00 | 39 | 0.08 | | 0.199 | 0.23 | 0.148 | 1.301 | 0 | 1 | 0 |
| 29/12/2015 12:00 | 35.38 | 0.09 | | 0.201 | 0.22 | 0.148 | 1.309 | 1 | 2 | 0 |
| 29/12/2015 13:00 | 35.13 | 0.08 | | 0.199 | 0.12 | 0.152 | 1.301 | 0 | 1 | 0 |
| 29/12/2015 14:00 | 34.25 | 0.08 | | 0.201 | 0.22 | 0.148 | 1.301 | 0 | 2 | 1 |
| 29/12/2015 15:00 | 34.63 | 0.09 | | 0.189 | 0.22 | 0.152 | 1.301 | 1 | 1 | 0 |
| 29/12/2015 16:00 | 36.38 | 0.08 | | 0.189 | 0.12 | 0.16 | 1.289 | 0 | 2 | 0 |
| 29/12/2015 17:00 | 36.63 | 0.08 | | 1.951 | 0.23 | 0.148 | 1.289 | 1 | 1 | 0 |
| 29/12/2015 18:00 | 31.88 | 0.08 | | 1.949 | 0.2 | 0.16 | 1.293 | 0 | 2 | 0 |
| 29/12/2015 19:00 | 26.25 | 0.09 | | 1.949 | 0.14 | 0.16 | 1.277 | 0 | 1 | 1 |
| 29/12/2015 20:00 | 26.25 | 0.08 | | 1.951 | 0.23 | 0.16 | 1.289 | 1 | 2 | 0 |
| 29/12/2015 21:00 | 27.13 | 0.08 | | 1.949 | 0.17 | 0.148 | 1.281 | 0 | 1 | 0 |
| 29/12/2015 22:00 | 26.25 | 0.09 | | 1.961 | 0.1 | 0.16 | 1.289 | 0 | 1 | 0 |
| 29/12/2015 23:00 | 26.75 | 0.08 | | 1.949 | 0.04 | 0.16 | 1.281 | 1 | 2 | 0 |
| 30/12/2015 00:00 | 17.38 | 0.08 | | 1.08 | 0.04 | 0.172 | 1.289 | 0 | 1 | 1 |
| 30/12/2015 01:00 | 16.38 | 0.09 | | 0.16 | 0.04 | 0.16 | 1.293 | 0 | 2 | 0 |
| 30/12/2015 02:00 | 17.38 | 0.08 | | 0.16 | 0.04 | 0.16 | 1.277 | 1 | 1 | 0 |
| 30/12/2015 03:00 | 17.5 | 0.09 | | 0.16 | 0.04 | 0.16 | 1.281 | 0 | 2 | 0 |
| 30/12/2015 04:00 | 15.88 | 0.08 | | 0.17 | 0.04 | 0.168 | 1.289 | 1 | 1 | 0 |
| 30/12/2015 05:00 | 16.63 | 0.08 | | 0.16 | 0.04 | 0.16 | 1.281 | 0 | 2 | 1 |
| 30/12/2015 06:00 | 23.75 | 0.09 | | 1.33 | 0.25 | 0.16 | 1.289 | 1 | 1 | 0 |
| 30/12/2015 07:00 | 28 | 0.08 | | 1.959 | 0.12 | 0.16 | 1.281 | 0 | 2 | 0 |
| 30/12/2015 08:00 | 27.63 | 0.08 | | 1.961 | 0.22 | 0.16 | 1.289 | 0 | 1 | 0 |
| 30/12/2015 09:00 | 34.38 | 0.09 | | 0.18 | 0.23 | 0.148 | 1.289 | 1 | 2 | 0 |
| 30/12/2015 10:00 | 33.88 | 0.08 | | 0.199 | 0.11 | 0.152 | 1.301 | 0 | 1 | 1 |
| 30/12/2015 11:00 | 34 | 0.08 | | 0.201 | 0.23 | 0.148 | 1.301 | 0 | 2 | 0 |
| 30/12/2015 12:00 | 33.38 | 0.09 | | 0.199 | 0.22 | 0.16 | 1.301 | 1 | 1 | 0 |
| 30/12/2015 13:00 | 40.13 | 0.08 | | 0.201 | 0.12 | 0.148 | 1.297 | 1 | 2 | 0 |
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| 30/12/2015 15:00 | 33.75 | 0.09 | | 0.199 | 0.23 | 0.16 | 1.301 | 0 | 2 | 0 |
| 30/12/2015 16:00 | 33.25 | 0.08 | | 0.182 | 0.12 | 0.16 | 1.301 | 1 | 1 | 0 |
| 30/12/2015 17:00 | 37.75 | 0.08 | | 1.949 | 0.22 | 0.16 | 1.281 | 0 | 2 | 0 |
| 30/12/2015 18:00 | 33 | 0.09 | | 1.961 | 0.23 | 0.16 | 1.289 | 1 | 1 | 0 |
| 30/12/2015 19:00 | 26.5 | 0.08 | | 1.959 | 0.13 | 0.172 | 1.289 | 0 | 2 | 1 |
| 30/12/2015 20:00 | 37.63 | 0.08 | | 1.949 | 0.22 | 0.16 | 1.281 | 0 | 1 | 0 |
| 30/12/2015 21:00 | 26.63 | 0.08 | | 1.961 | 0.18 | 0.148 | 1.289 | 1 | 2 | 0 |
| 30/12/2015 22:00 | 27.25 | 0.08 | | 1.949 | 0.1 | 0.16 | 1.289 | 0 | 1 | 0 |
| 30/12/2015 23:00 | 26.75 | 0.09 | | 1.951 | 0.04 | 0.16 | 1.281 | 0 | 2 | 0 |
| 31/12/2015 00:00 | 17.75 | 0.08 | | 1.07 | 0.04 | 0.172 | 1.281 | 1 | 1 | 1 |
| 31/12/2015 01:00 | 16.88 | 0.08 | | 0.17 | 0.04 | 0.16 | 1.289 | 0 | 1 | 0 |
| 31/12/2015 02:00 | 18.25 | 0.08 | | 0.16 | 0.04 | 0.168 | 1.277 | 1 | 2 | 0 |
| 31/12/2015 03:00 | 18.25 | 0.09 | | 0.158 | 0.04 | 0.16 | 1.281 | 0 | 1 | 0 |
| 31/12/2015 04:00 | 17.38 | 0.08 | | 0.16 | 0.04 | 0.16 | 1.289 | 0 | 2 | 0 |
| 31/12/2015 05:00 | 17.63 | 0.08 | | 0.16 | 0.03 | 0.16 | 1.281 | 1 | 2 | 1 |
| 31/12/2015 06:00 | 22.13 | 0.08 | | 1.33 | 0.23 | 0.148 | 1.281 | 0 | 1 | 0 |
| 31/12/2015 07:00 | 28.38 | 0.08 | | 1.941 | 0.12 | 0.152 | 1.277 | 0 | 1 | 0 |
| 31/12/2015 08:00 | 29 | 0.09 | | 1.949 | 0.22 | 0.148 | 1.293 | 1 | 2 | 0 |
| 31/12/2015 09:00 | 35.88 | 0.08 | | 0.199 | 0.23 | 0.172 | 1.297 | 0 | 1 | 0 |
| 31/12/2015 10:00 | 35 | 0.08 | | 0.201 | 0.12 | 0.16 | 1.301 | 1 | 2 | 1 |
| 31/12/2015 11:00 | 38.63 | 0.09 | | 0.199 | 0.23 | 0.148 | 1.301 | 0 | 1 | 0 |
| 31/12/2015 12:00 | 38 | 0.08 | | 0.201 | 0.22 | 0.16 | 1.301 | 0 | 2 | 0 |
| 31/12/2015 13:00 | 33.13 | 0.08 | | 0.199 | 0.12 | 0.148 | 1.301 | 1 | 1 | 0 |
| 31/12/2015 14:00 | 52.88 | 0.09 | | 0.199 | 0.22 | 0.152 | 1.297 | 0 | 2 | 1 |
| 31/12/2015 15:00 | 36 | 0.08 | | 0.201 | 0.23 | 0.16 | 1.301 | 1 | 1 | 0 |
| 31/12/2015 16:00 | 35.5 | 0.08 | | 0.199 | 0.12 | 0.16 | 1.301 | 0 | 2 | 0 |
| 31/12/2015 17:00 | 47.13 | 0.09 | | 1.93 | 0.22 | 0.16 | 1.289 | 1 | 1 | 0 |
| 31/12/2015 18:00 | 34 | 0.08 | | 1.951 | 0.22 | 0.148 | 1.293 | 0 | 1 | 1 |
| 31/12/2015 19:00 | 22.88 | 0.08 | | 1.07 | 0.04 | 0.16 | 1.277 | 0 | 2 | 0 |
| 31/12/2015 20:00 | 21.25 | 0.09 | | 0.158 | 0.04 | 0.16 | 1.289 | 1 | 1 | 0 |
| 31/12/2015 21:00 | 22.38 | 0.08 | | 0.172 | 0.04 | 0.168 | 1.293 | 0 | 2 | 0 |
| 31/12/2015 22:00 | 17.63 | 0.09 | | 0.158 | 0.04 | 0.16 | 1.289 | 0 | 1 | 0 |
| 31/12/2015 23:00 | 17.25 | 0.08 | | 0.16 | 0.04 | 0.172 | 1.281 | 1 | 2 | 1 |
| 01/01/2016 00:00 | 17.25 | 0.09 | | 0.16 | 0.04 | 0.16 | 1.289 | 0 | 1 | 0 |
| 01/01/2016 01:00 | 18.63 | 0.08 | | 0.17 | 0.04 | 0.16 | 1.281 | 1 | 2 | 0 |
| 01/01/2016 02:00 | 17.63 | 0.08 | | 0.16 | 0.04 | 0.168 | 1.289 | 0 | 1 | 0 |
| 01/01/2016 03:00 | 17.75 | 0.09 | | 0.16 | 0.04 | 0.16 | 1.277 | 0 | 2 | 0 |
| 01/01/2016 04:00 | 17.38 | 0.08 | | 0.17 | 0.04 | 0.172 | 1.293 | 1 | 1 | 1 |
| 01/01/2016 05:00 | 18 | 0.08 | | 0.16 | 0.04 | 0.16 | 1.277 | 0 | 2 | 0 |
| 01/01/2016 06:00 | 23.13 | 0.09 | | 1.32 | 0.25 | 0.148 | 1.293 | 0 | 1 | 0 |

# Energy Audit – Site Visit


# AFTER ENERGY AUDIT

## Pilot Site Example – SASMI Building, Gateshead College

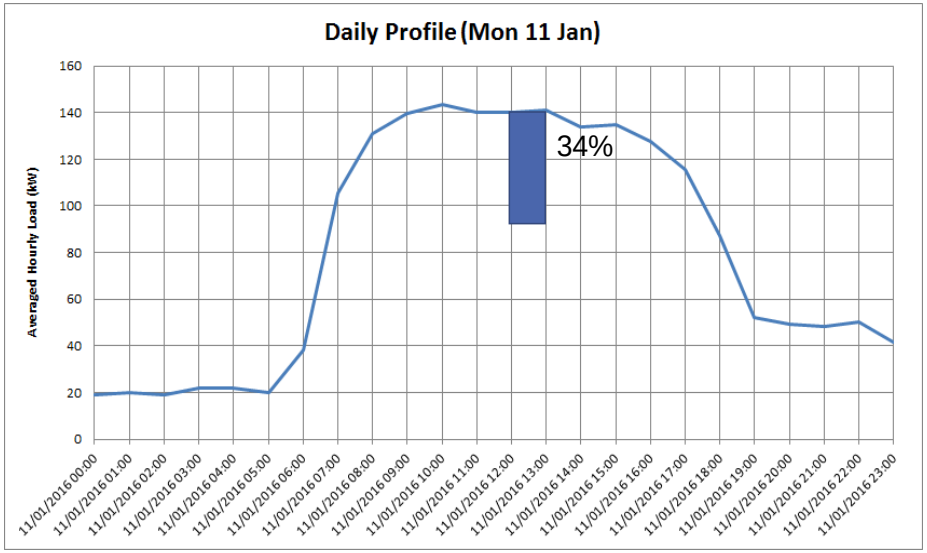
Existing Building

- 5,713 $m^2$ Classrooms, offices (3,423 $m^2$), workshops
- Construction completed 2011
- Energy Performance Certificate: C
- Electrical Load: 140kW peak load, 20kW base load
- Heating: Mainly Gas direct burners,
  VRF spilt units in classrooms & offices
- Ventilation: 5 AHUs, VSDs on fans
- Cooling: VRF split units, DX split units AHU-01
- DHS: Gas fired direct hot water cylinders
- Lighting: Indoor locally switched,
  External on BMS, Lux, time, on/off control
- Other loads: door curtain, air compressor

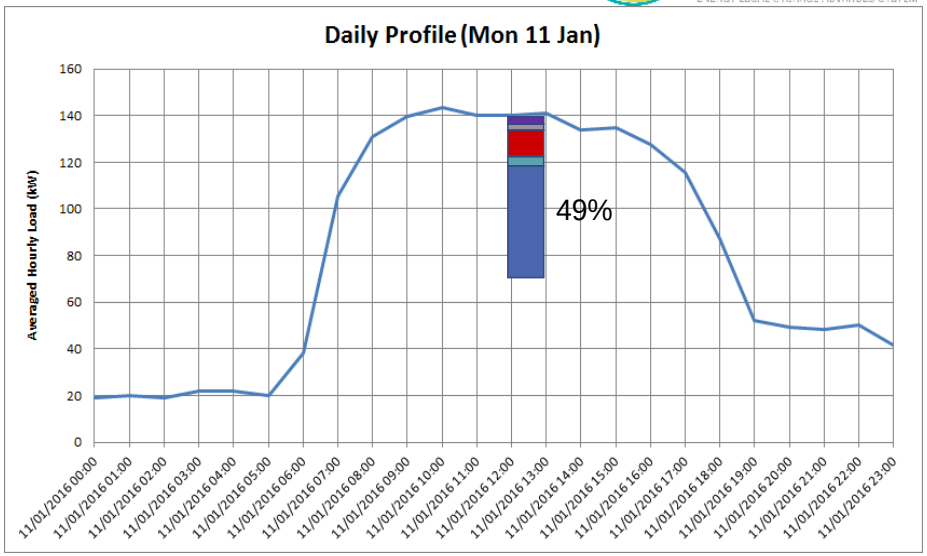
ELSA Installations

- 16 x 3 = 48 kWh 2nd life batteries
  (NISSAN Leaf Gen 1)
- 40 - 50 kWp PV
- UTRCI ICT System

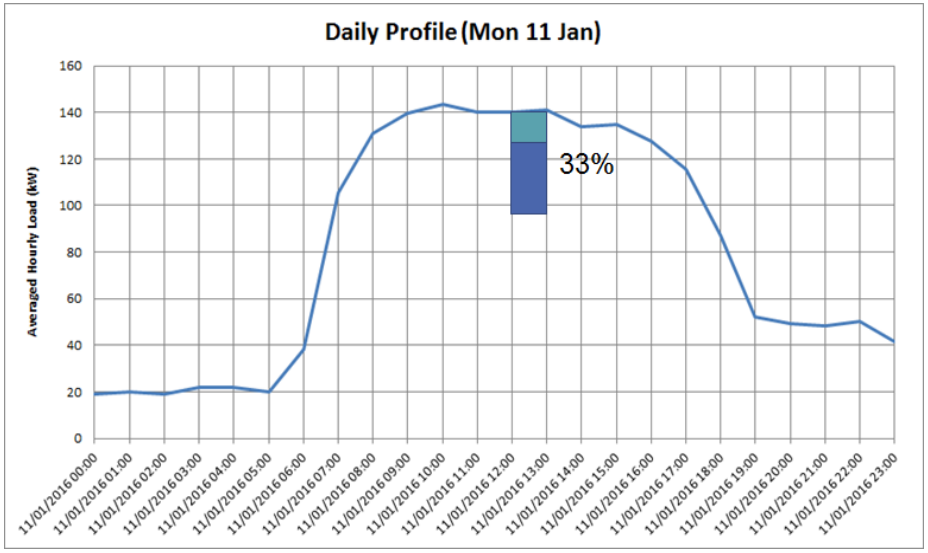
# Flexibility Scenario – 1 Hour Event



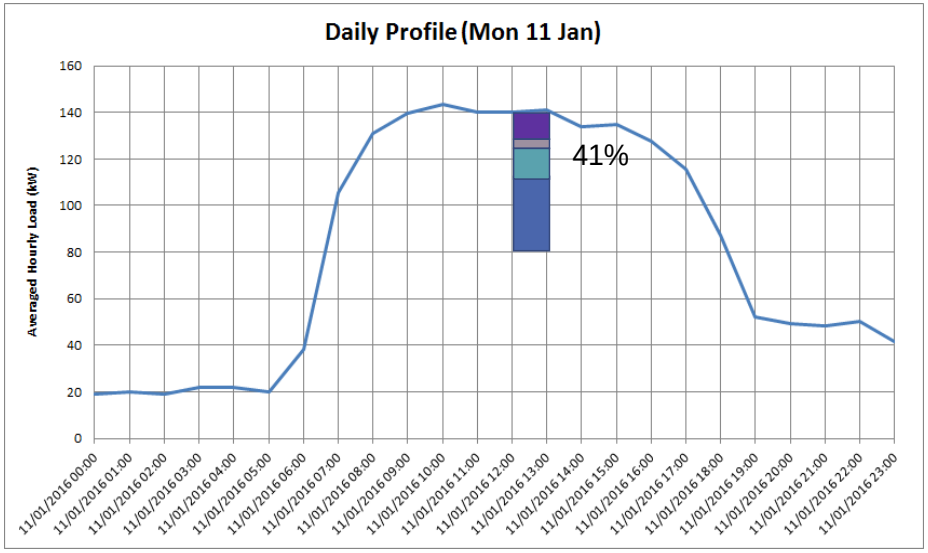

Battery System Only; Source: UTRCI




Battery, PV, 10% HVAC Reduction & Door Curtain Winter; Source: UTRCI

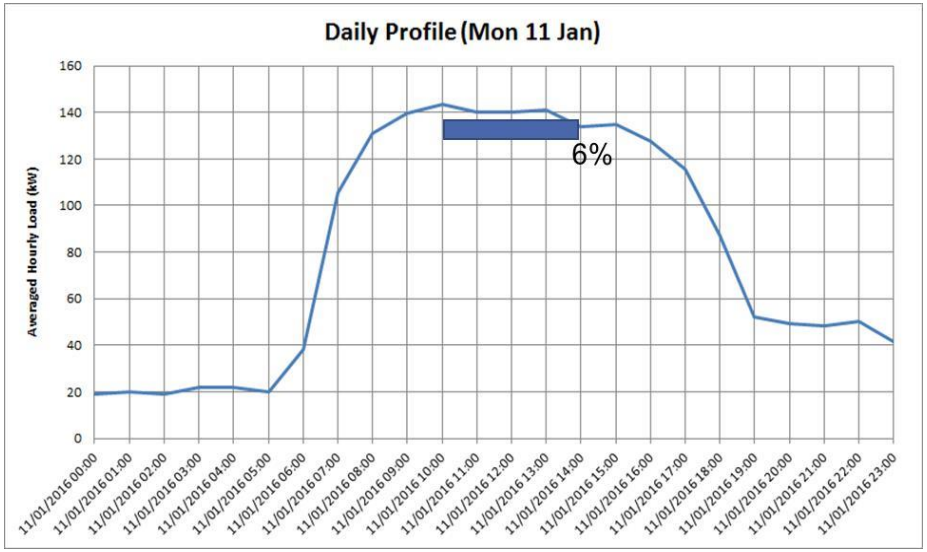



Battery & PV peak output Summer; Source: UTRCI

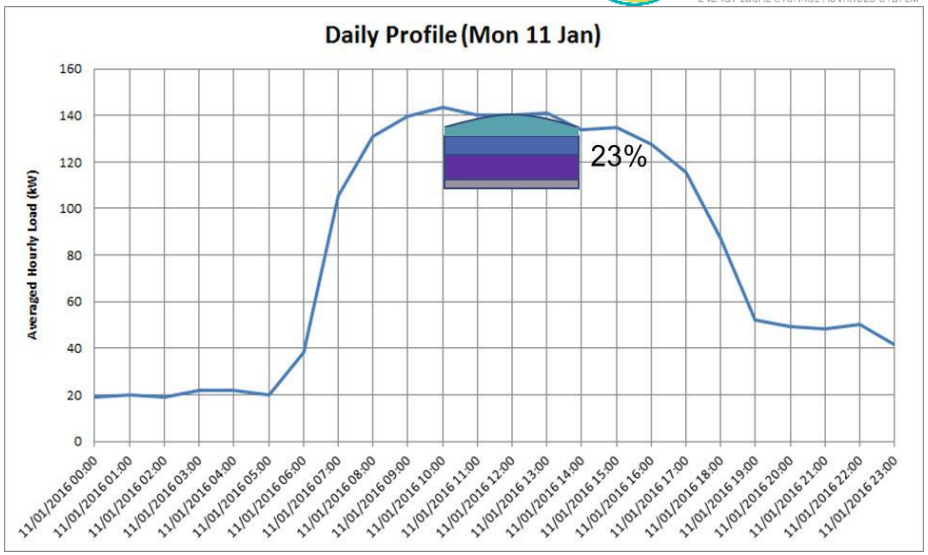



Battery, PV, 20% HVAC Reduction Summer; Source: UTRCI

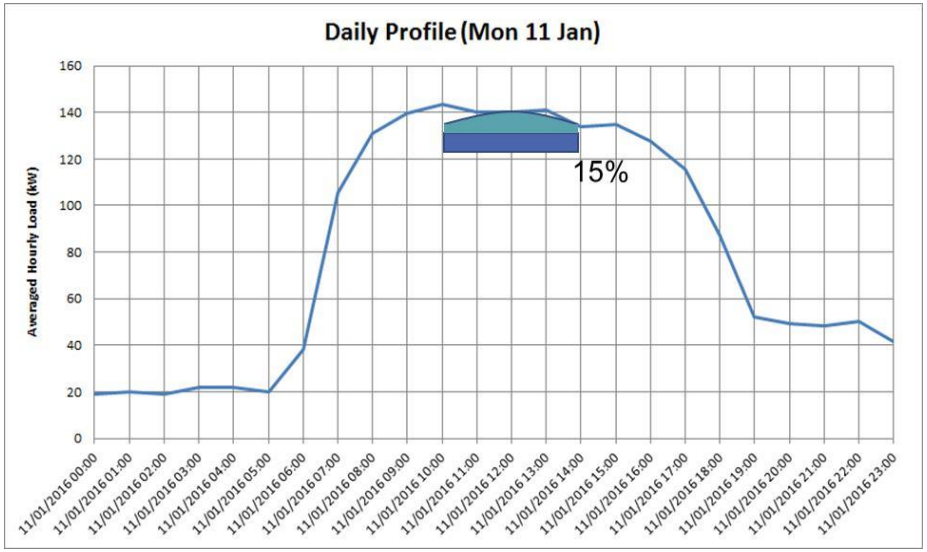
# Flexibility Scenario – 4 Hour Event



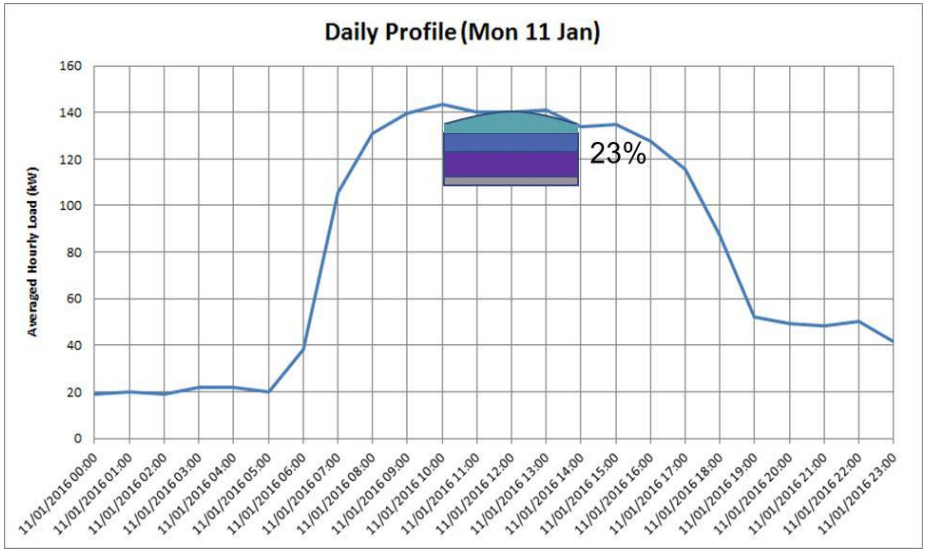

Battery System Only; Source: UTRCI




Battery, PV, 10% HVAC Reduction & Door Curtain Winter; Source: UTRCI



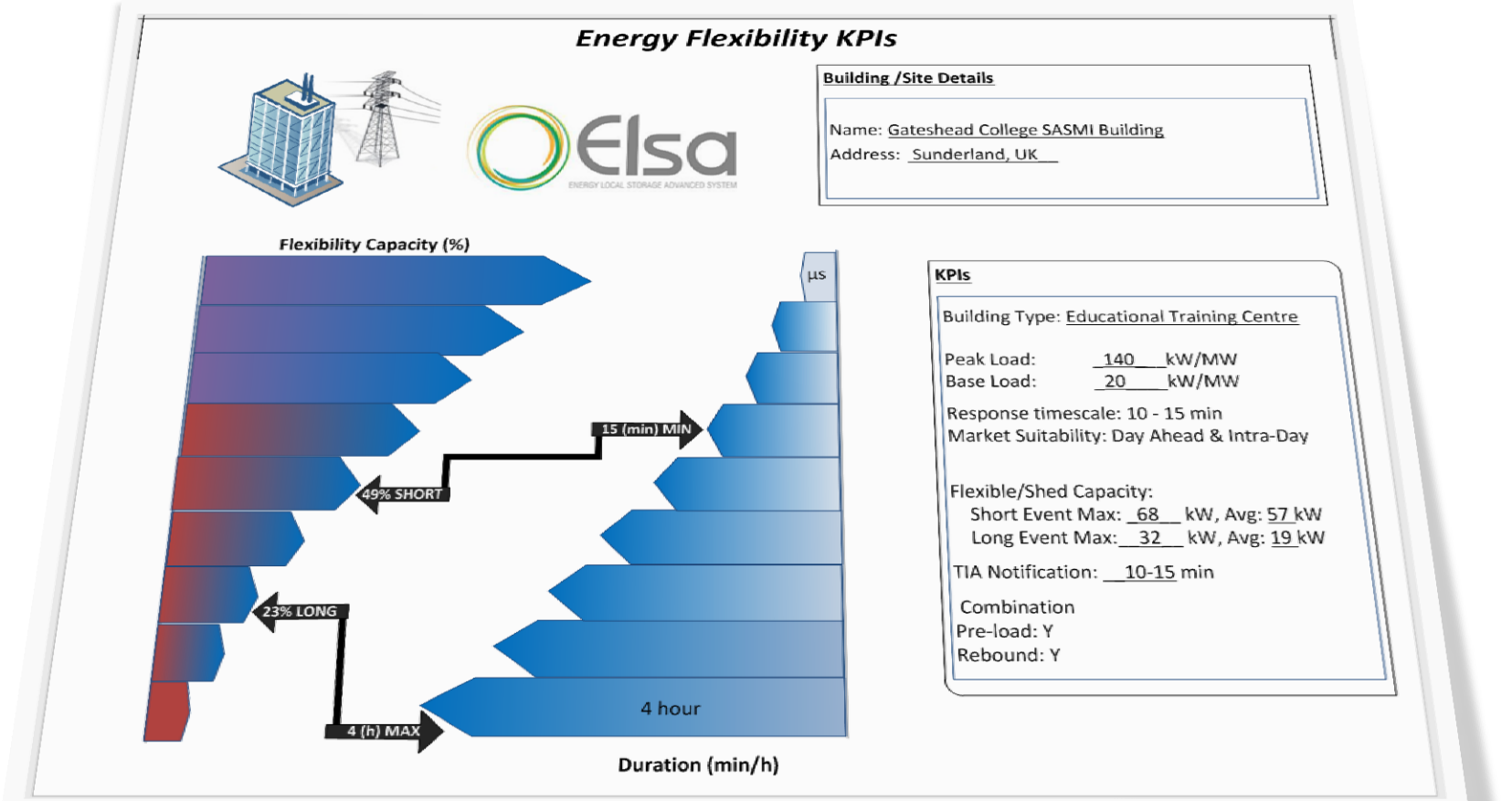

Battery & PV peak output Summer; Source: UTRCI




Battery, PV, 20% HVAC Reduction Summer; Source: UTRCI

# Benchmark Comparison & KPIs

| Benchmark 1 (Piette et al. 2006) | Benchmark 2 (Siebert et al. 2015) | SASMI GC Site Flexibility (%) | Duration (h/min) |
|---|---|---|---|
| Average 7 – 9 % | Average ~ 12 % | Average 14 % | 4 h |
| - | Min ~ 7 % | Min 8 % | 4 h |
| Max 28 - 56 % | Max ~ 18 % | Max 49 % | 1 h |



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