Flexibility Analysis for Smart Grid Demand Side Services Incorporating 2nd Life EV Batteries

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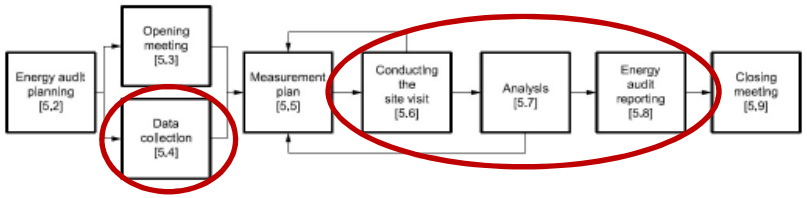
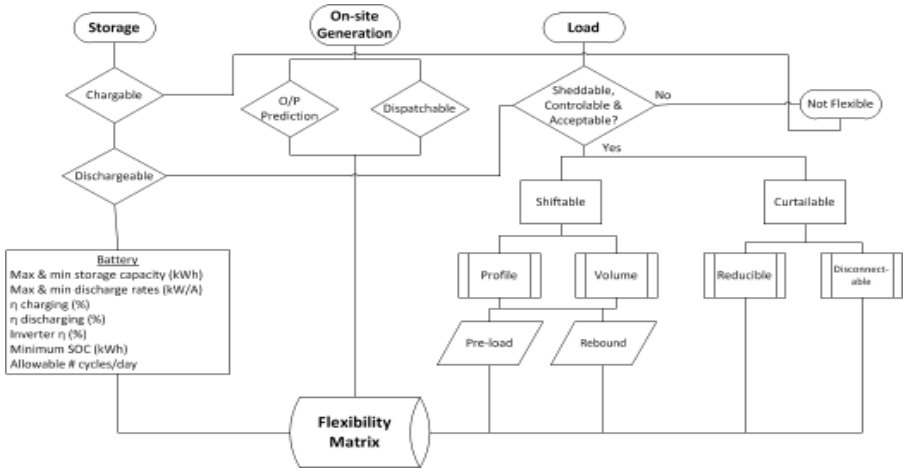
FLEXIBILITY ASSESMENT OVERVIEW

Methodology developed & implemented at Gateshead College

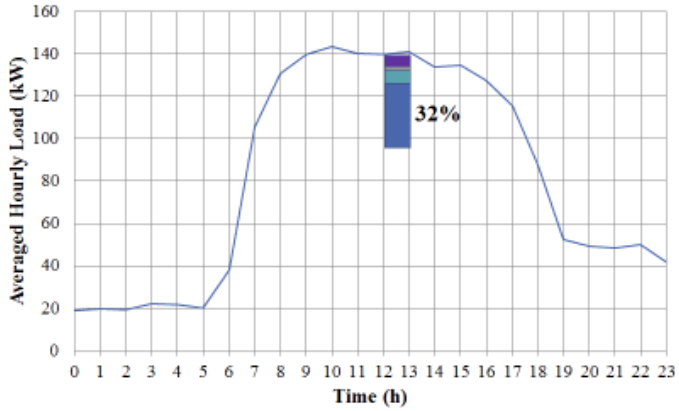
Step 1. System & Load Identification
ISO 50002:2014 Energy Audit process adapted for flexibility



Step 2. Flexibility Characterisation
Assessment methodology developed



Step 3. Flexibility Scenarios
Estimates of 1 & 4 hour events



Step 4. Benchmark Comparison
v's other demonstration studies

Benchmark 1 (Piette et al. 2006)	Benchmark 2 (Siebert et al. 2015)	SASMI, Gateshead College Site Flexibility (%)	Duration (h)
Average 7 – 9 %	Average ~ 12 %	**Average 8 - 15 %**	4 h
-	Min ~ 7 %	**Min 8 %**	4 h
Max 28 - 56 %	Max ~ 18 %	**Max 32 %**	1 h

METHODOLOGY DEVELOPMENT

Definition, Literature Review & Origins of methodology

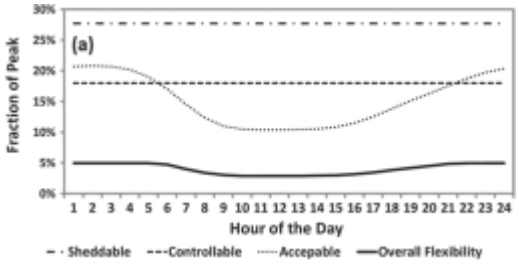
Flexibility Definition: (IEA Annex 67, due 2019)

Interim definition: Modifying (decreasing or increasing) the electrical load profile through load shedding, ramping up, on site generation and storage, implemented using automatic control of systems, while minimising the impact on occupants and operations.

Approaches in literature:

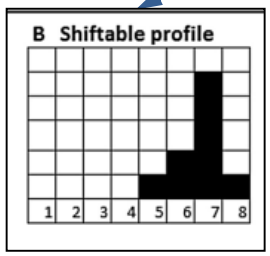
a. Formula

$$F_{l,p}(t) = S_{l,p}(t) \cdot min\left[C_{l,p}(t), A_{l,p}(t)\right] \quad [1]$$

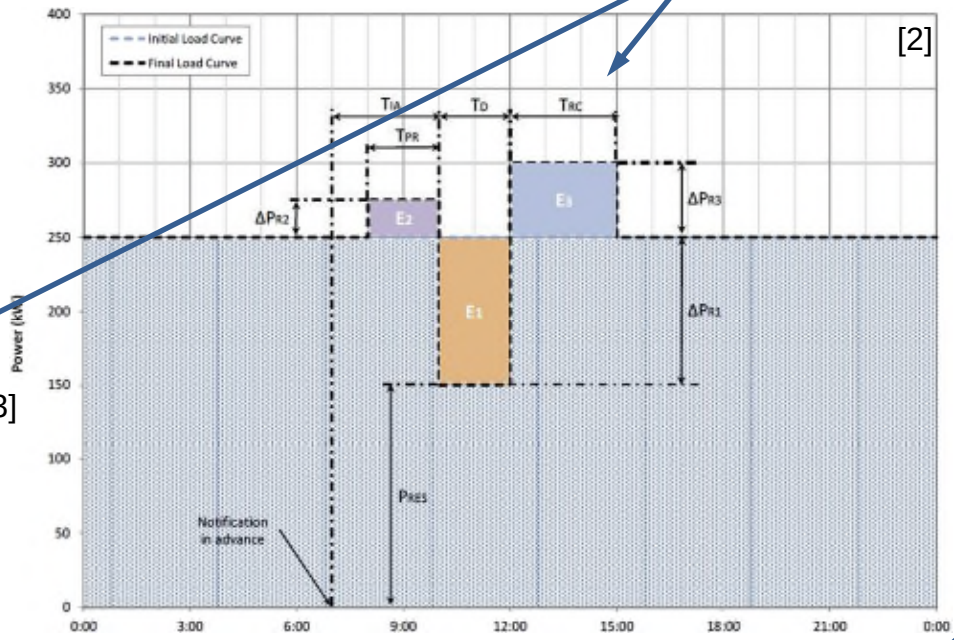


Sheddable (S);
Controllable (C);
Acceptable (A)

b. Parameter (constraint) representation differs across sources



[3]

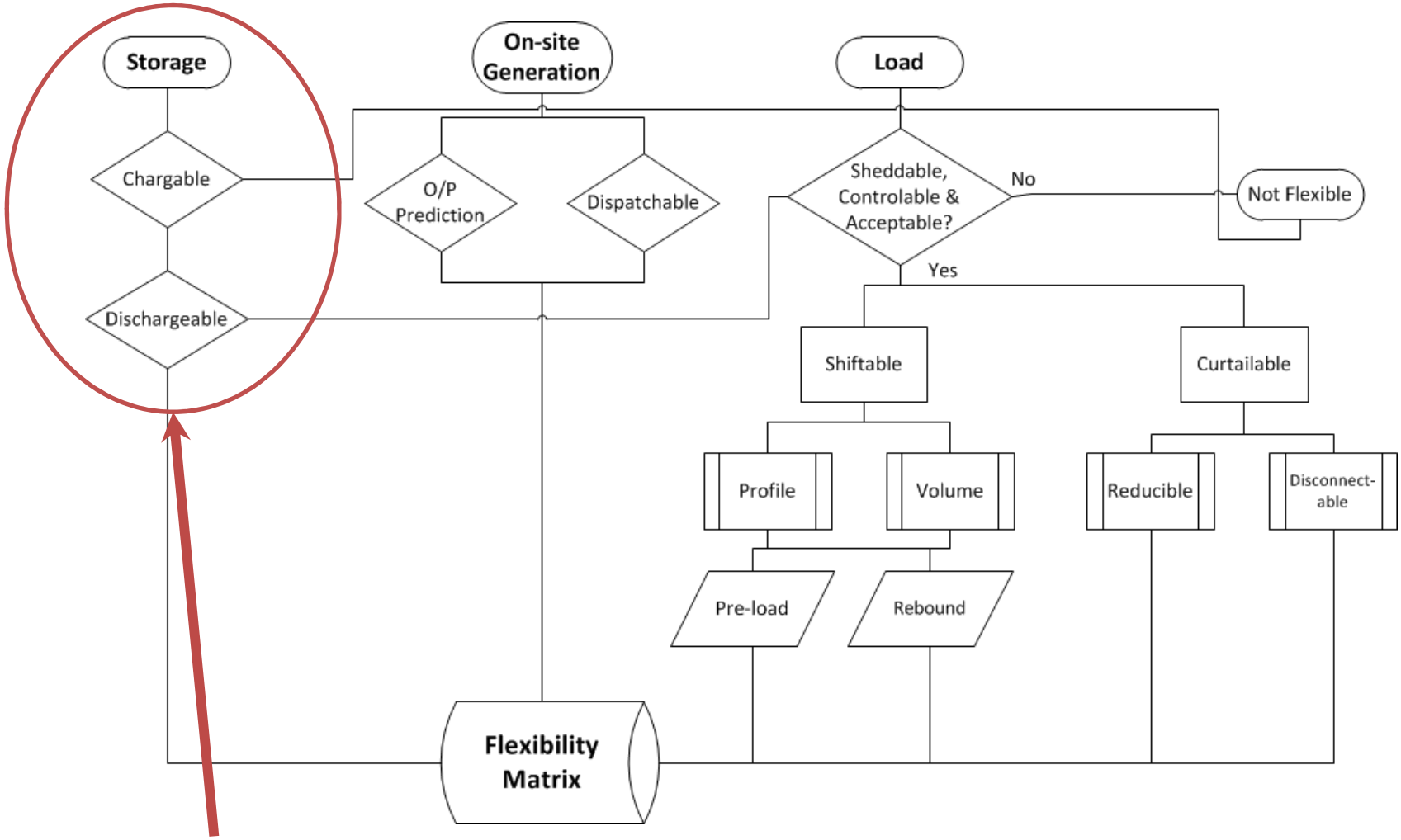


[2]

1. O. Ma, N. Alkadi, P. Cappers, P. Denholm, J. Dudley, S. Goli, *et al., "Demand Response for Ancillary Services," IEEE Transactions on Smart Grid, vol. 4, pp. 1988-1995, 2013.*
2. Alcázar-Ortega, M., Calpe, C., Theisen, T., Rodríguez-García, J. (2015a). "Certification prerequisites for activities related to the trading of demand response resources." Energy 93, Part 1: 705-715.
3. Ottesen, S. O. and Tomasgard A. (2015). "A stochastic model for scheduling energy flexibility in buildings." Energy 88: 364-376

FLEXIBILITY CHARACTERISATION PROCESS

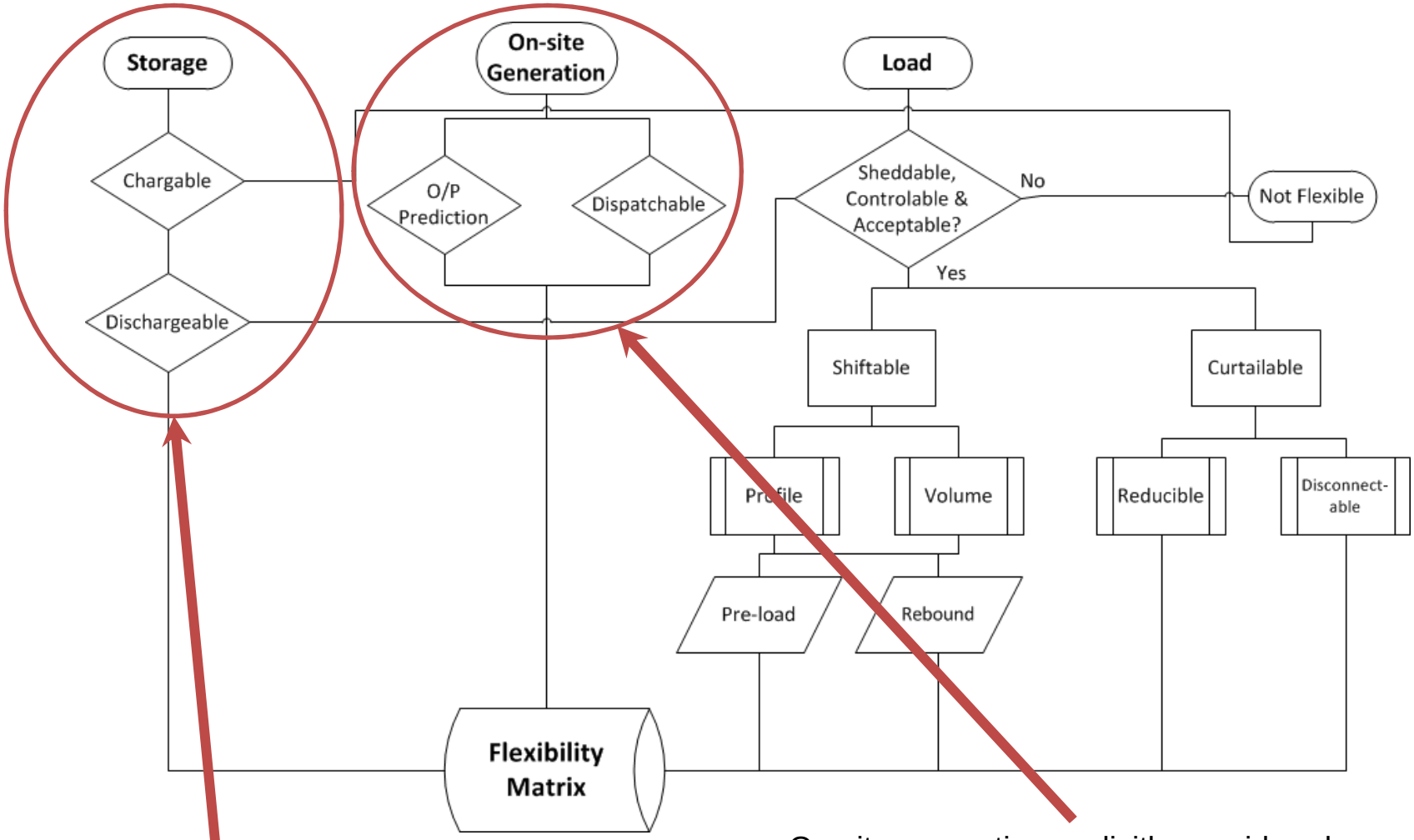
Fast, easily implementable, standardised methodology



Storage flexibility explicitly considered

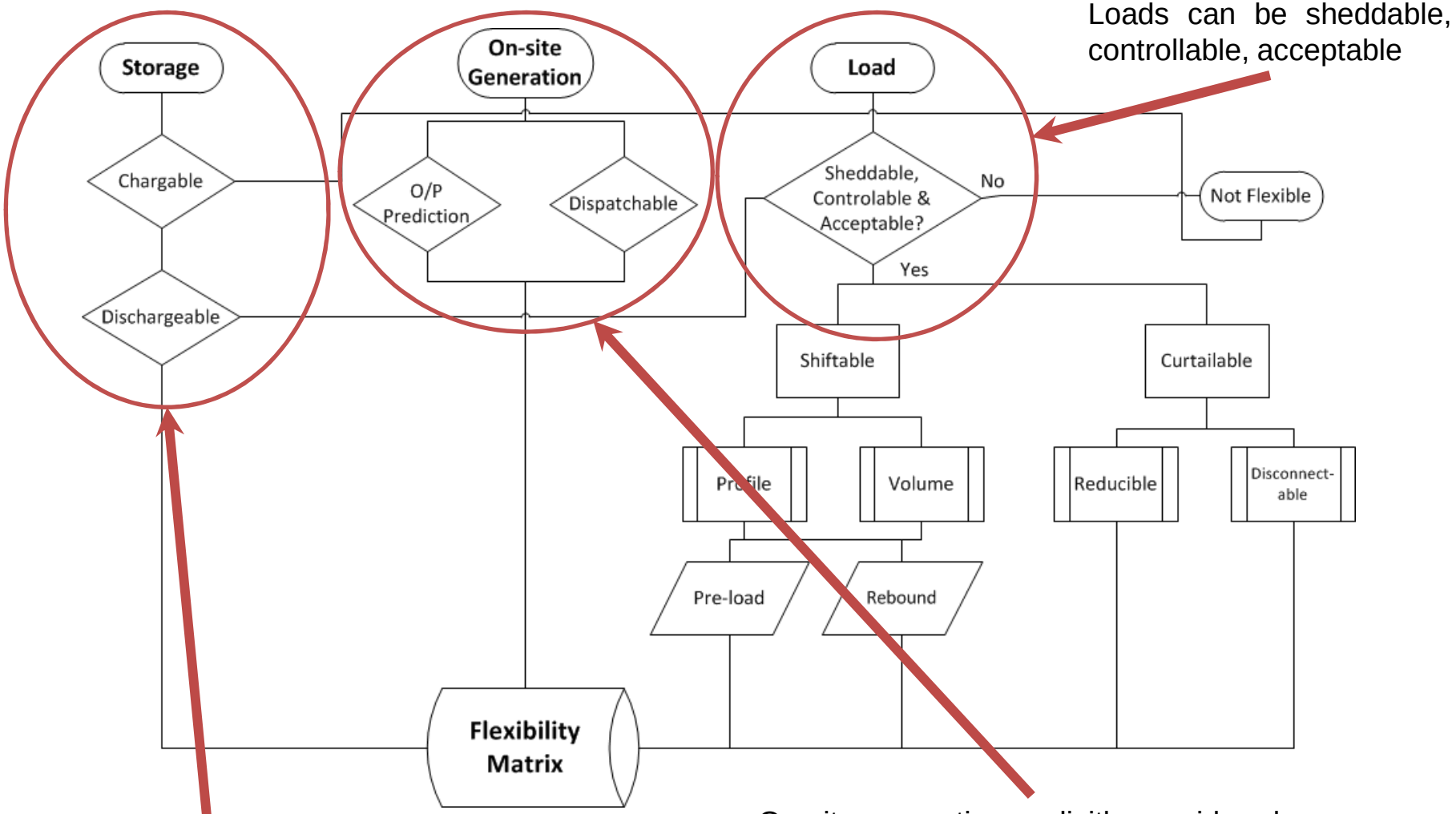
FLEXIBILITY CHARACTERISATION PROCESS

Fast, easily implementable, standardised methodology



FLEXIBILITY CHARACTERISATION PROCESS

Fast, easily implementable, standardised methodology



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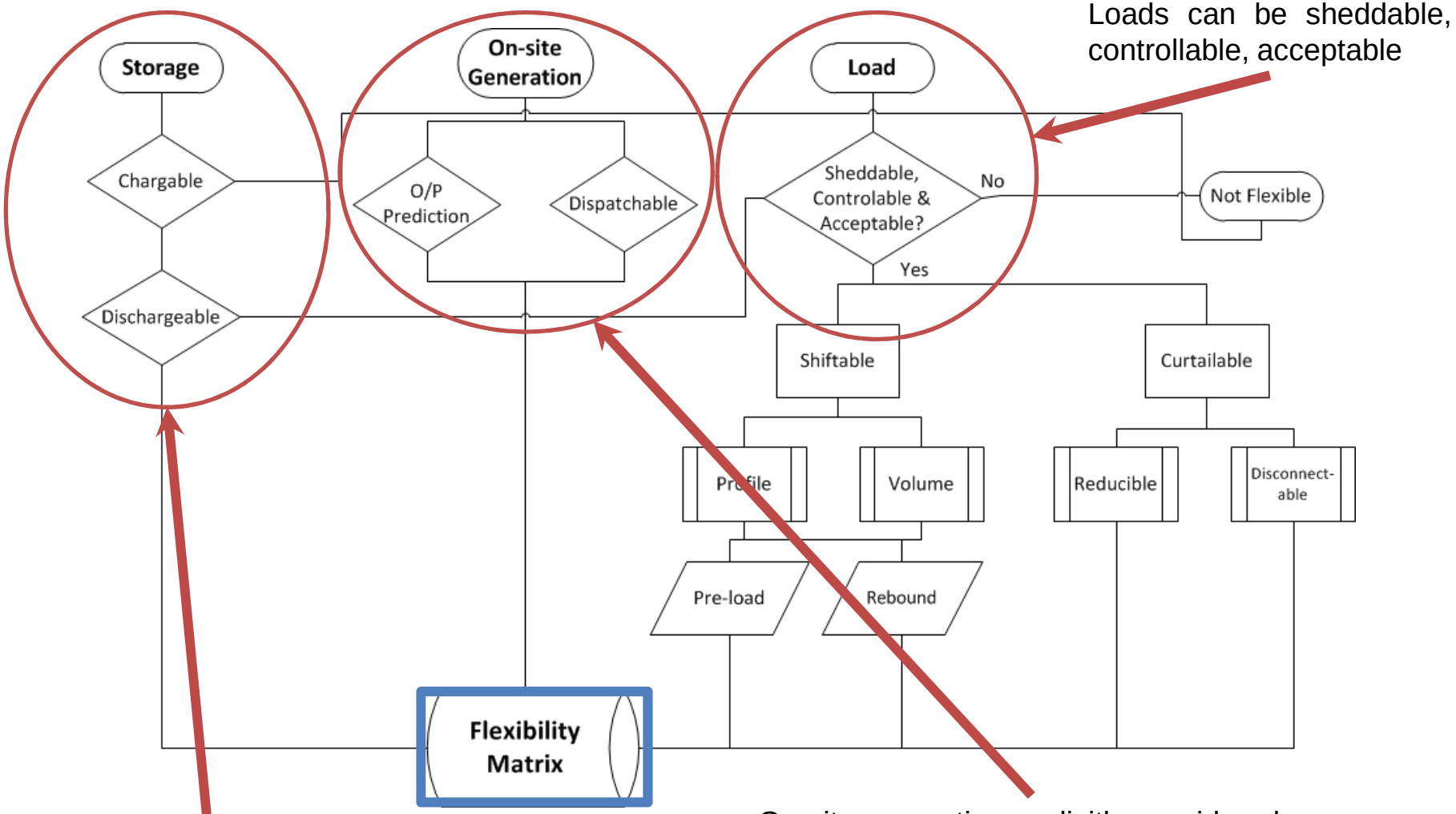


SYSTEM & LOAD IDENTIFICATION

Flexibility Energy Audit, SASMI Building, Gateshead College, Sunderland, UK

Before the Energy Audit

ELSA Installations

- 16kWh x 3 = 48kWh 2nd life batteries
  (ex 3 x 24kWh Nissan Leaf)
- 40kWp PV
- UTRCI ICT System

After the Energy Audit

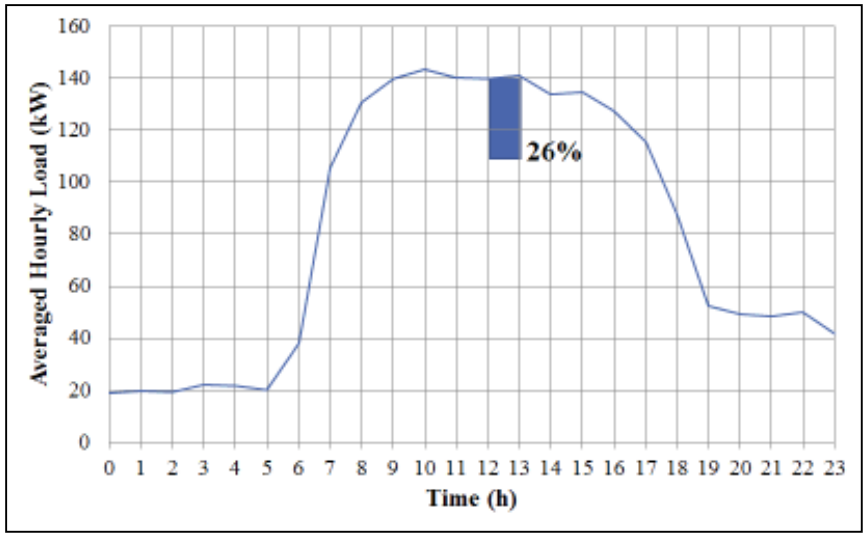
Existing Building

- 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

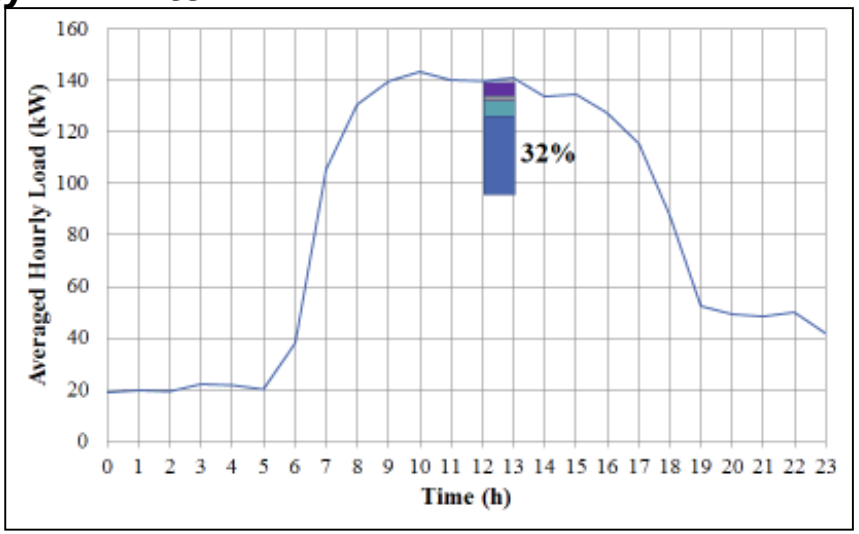
FLEXIBILITY SCENARIOS

for Pilot Site SASMI, Gateshead College

1 Hour Flexibility in Winter

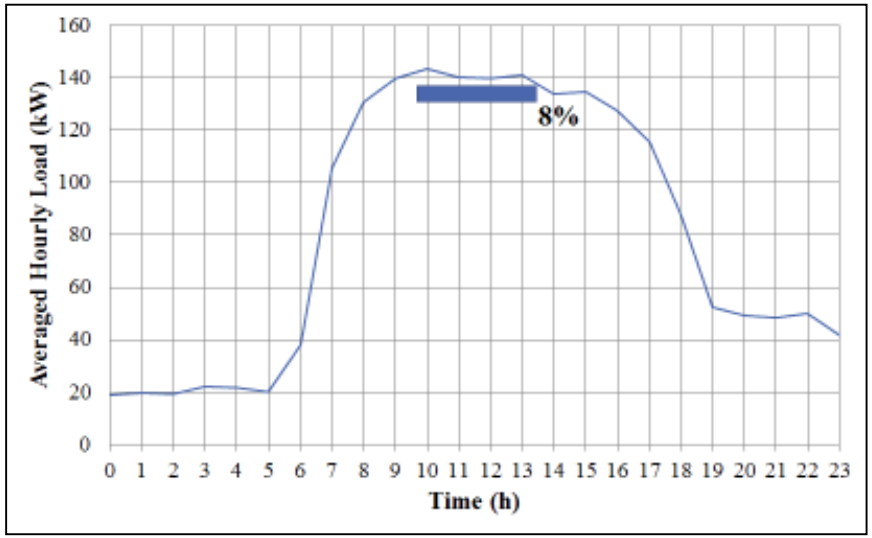


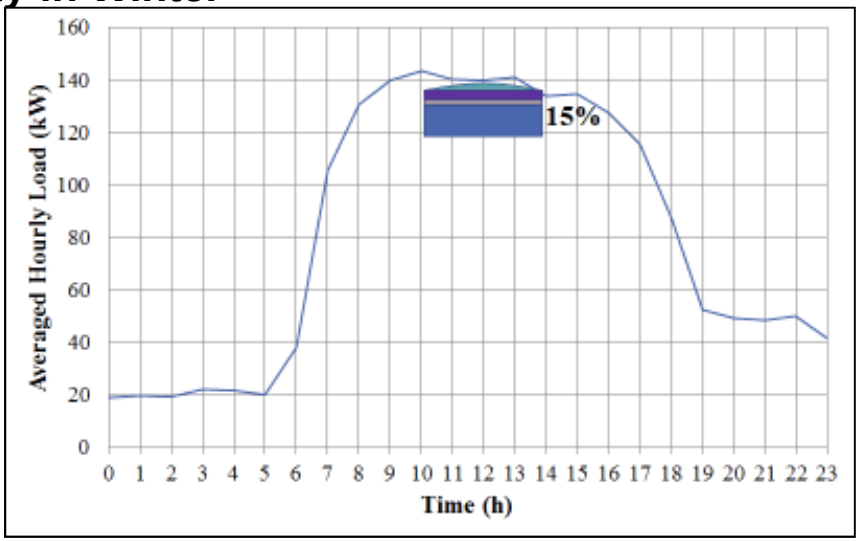
Battery System Only



Battery, PV & 10% HVAC Reduction (VRF & AHU Fans)

4 Hour Flexibility in Winter





BENCHMARKING

Comparison of Results from Pilot Site with published data

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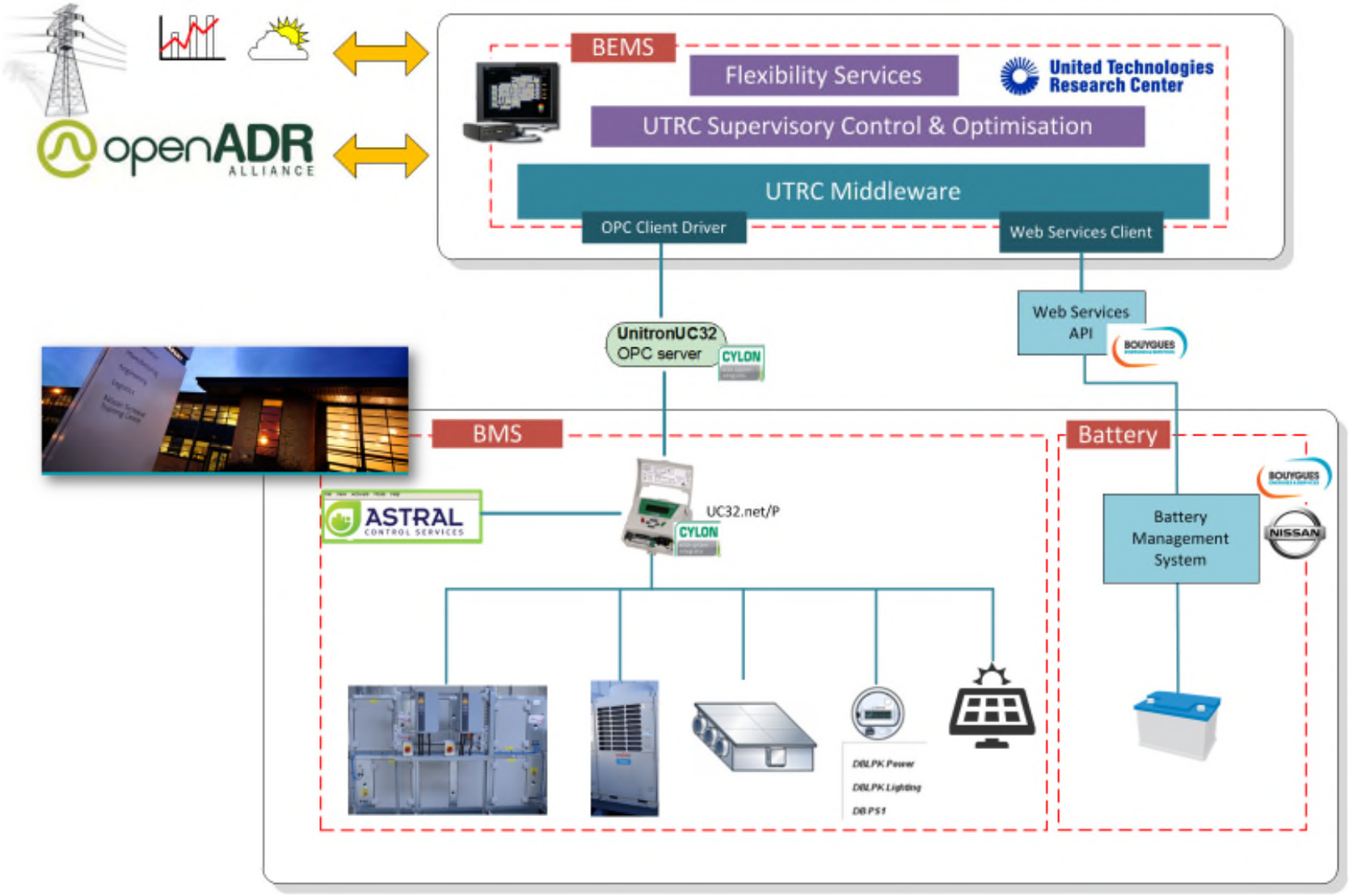
4. M.A. Piette, D. Watson, N. Motegi, S. Kiliccote, and E. Linkugel. "*Automated Demand Response Strategies and Commissioning Commercial Building Controls*." National Conference on Building Commissioning. April 2006.
5. P. Xu, and L. Zagreus. "Demand Shifting with Thermal Mass in Light & Heavy Mass Commercial Buildings." ASHRAE Annual Conference. Louisville, KY, June 2009.

UTRCI ICT SYSTEM ARCHITECTURE



Energy Local Storage Advanced system

- H2020 project: combining 2nd life EV batteries with energy management systems for buildings and districts to deliver DSM services

- UTRCI role: Mature and pilot an ICT platform based Building Energy Management System (BEMS) that optimally coordinates building loads, local generation and energy storage (with 2nd life batteries) to enable demand response and other ancillary grid services.

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