CoolDown

A Strategic Innovation Fund Discovery Phase Project

WP3.1 Review and recommend update to assumptions and inputs to DFES modelling related to Space Cooling

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Project Partners:

Guidehouse

University College London Consultancy

Version

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0.1	06/05/24	Delroy Ainsworth	Draft	
0.2	17/05/24	Michael Keddy	Draft	Internal review
0.3	20/05/24	Chris Greenfield	Draft	Internal review
1.0	21/05/24	Delroy Ainsworth	Final	

Contents

Glossary

AC	Air Conditioning
DFES	Distribution Future Electricity Scenarios
DG	Distributed Generation
DR	Demand Response
ESO	Energy System Operator
EV	Electric Vehicle
FES	Future Energy Scenarios
SC	Space Cooling
SIF	Strategic Innovation Fund
UCLC	University College London Consultancy
WP	Work Package

1 Introduction

The Strategic Innovation Fund (SIF) is supporting network innovation that contributes to the achievement of net zero, while delivering net benefits to energy consumers. Ofgem sets the strategic innovation challenges and invites applications for projects to address them. To mitigate the risk associated with innovation, the innovation is funded in three phases:

1. *Discovery phase (feasibility studies):* define the problem and the value in solving the problem.

2. *Alpha phase (experimental development):* focus on preparing and testing the different solutions identified during the discovery phase.

3. *Beta phase (build, operation and/or demonstration):* focus on the deployment of the solution to the problem.

CoolDown was submitted as a solution to address the SIF Round 2 Challenge 3: Unlocking energy system flexibility to accelerate electrification of heat.

2 CoolDown overview

As Britain warms due to climate change, electrification of heat will mean increasing customer access to space cooling leading to increased summer peak demands. In current distribution network planning cooling demand is currently poorly accounted for and based on limited, high-level modelling. Additionally, cooling's potential to provide flexibility during periods of network stress has not been considered.

CoolDown will, for the first time, explore the impact of cooling on network capacity by producing improved uptake and demand projections as well as developing novel commercial models to incentivise and unlock space-cooling flexibility, reducing network reinforcement requirements and optimising value for customers.

This discovery phase is being led by Electricity North West, and principally delivered by Guidehouse and University College London Consultancy (UCLC).

This discovery phase project will be delivered through 5 work packages (WP):

- WP1 - Project Management and Governance
- WP2 - Modelling cooling uptake and demand
- WP3 - Exploring Network Impact of Space Cooling
- WP4 - Evaluating cooling demand response (DR)
- WP5 - Longlisting commercial models

This report addresses a deliverable as part of WP3: Review and recommend updates to assumptions and inputs to Distribution Future Electricity Scenarios (DFES) modelling related to space cooling.

3 DFES overview

The DFES are long-term forecasts of electricity demand supplied by our distribution network, as well as forecasts of distributed generation (DG) and battery storage connected to our networks.

Our DFES 2023 consists of five scenarios:

- Falling Short
- System Transformation
- Best View
- Consumer Transformation
- Leading the Way

Four follow the common scenario framework of the 2023 Future Energy Scenarios (FES) from the Energy System Operator (ESO). The Best View scenario focuses on the highest certainty trends in our region through to 2030. Beyond 2030 the higher certainty range of electricity demand is defined by the common scenarios that model high levels of electrification (Leading the Way and Consumer Transformation).

The initial four scenarios are aligned to the Future Energy Scenarios (FES), produced by the ESO, in terms of speed of decarbonisation and level of societal change.

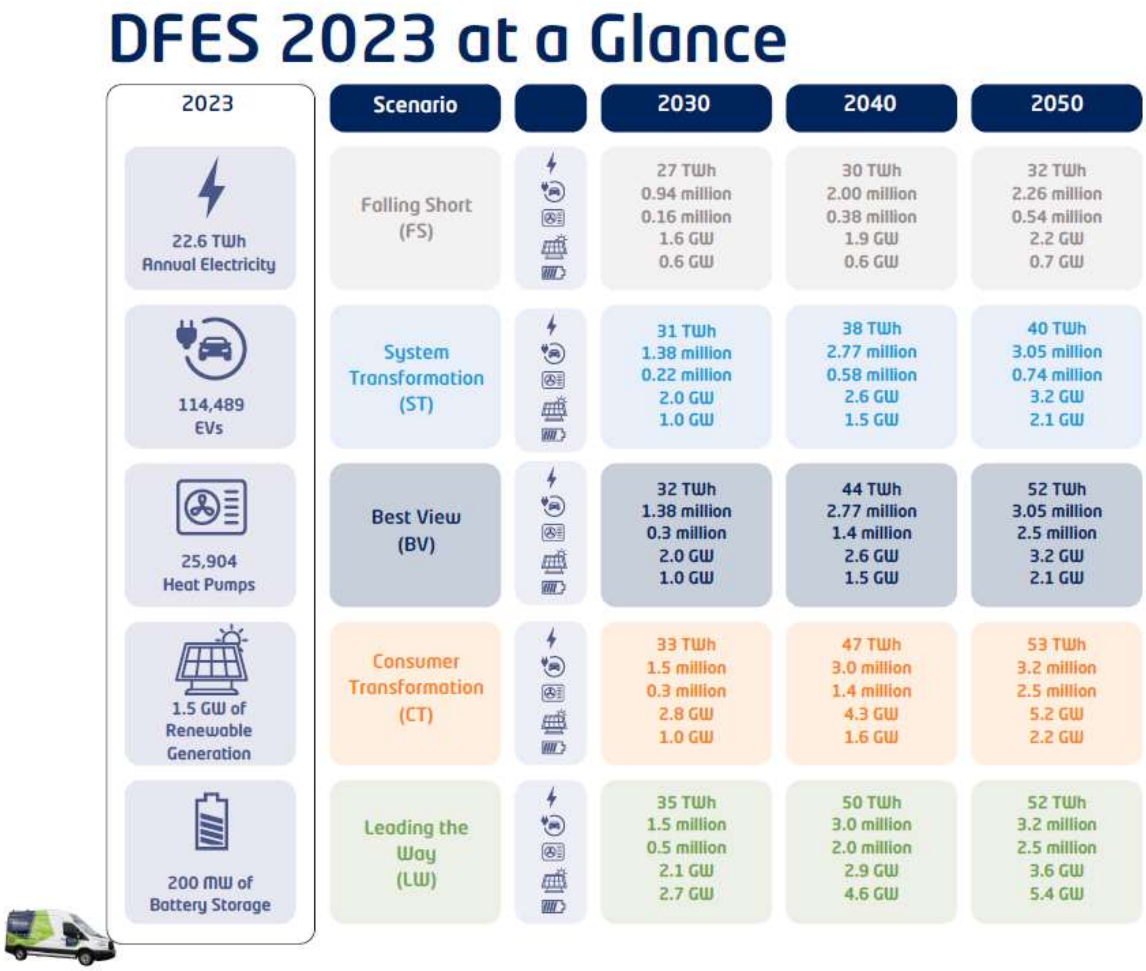
All scenarios specifically represent the North West and are modelled using regional data and learnings from our engagement with local stakeholders, as well as our unique bottom up methodology developed as part of our ATLAS Network Innovation Allowance project.

Best View, offers the highest level of certainty until 2030, diminishing over the following decade, and decreasing further until 2050.

Each of these scenarios contain different assumptions regarding:

- Annual Electricity consumption
- Electric Vehicle (EV) uptake
- Heat Pump (HP) Uptake
- Amount of Renewable Generation
- Battery storage capacity

Figure 1 shows these 5 scenarios compared.



DFES 2023 at a Glance

2023	Scenario	2030	2040	2050
22.6 TWh Annual Electricity	Falling Short (FS)	27 TWh 0.94 million 0.16 million 1.6 GW 0.6 GW	30 TWh 2.00 million 0.38 million 1.9 GW 0.6 GW	32 TWh 2.26 million 0.54 million 2.2 GW 0.7 GW
114,489 EVs	System Transformation (ST)	31 TWh 1.38 million 0.22 million 2.0 GW 1.0 GW	38 TWh 2.77 million 0.58 million 2.6 GW 1.5 GW	40 TWh 3.05 million 0.74 million 3.2 GW 2.1 GW
25,904 Heat Pumps	Best View (BV)	32 TWh 1.38 million 0.3 million 2.0 GW 1.0 GW	44 TWh 2.77 million 1.4 million 2.6 GW 1.5 GW	52 TWh 3.05 million 2.5 million 3.2 GW 2.1 GW
1.5 GW of Renewable Generation	Consumer Transformation (CT)	33 TWh 1.5 million 0.3 million 2.8 GW 1.0 GW	47 TWh 3.0 million 1.4 million 4.3 GW 1.6 GW	53 TWh 3.2 million 2.5 million 5.2 GW 2.2 GW
200 MW of Battery Storage	Leading the Way (LW)	35 TWh 1.5 million 0.5 million 2.1 GW 2.7 GW	50 TWh 3.0 million 2.0 million 2.9 GW 4.6 GW	52 TWh 3.2 million 2.5 million 3.6 GW 5.4 GW

Figure 1: Comparison of the 5 scenarios

4 DFES and Space Cooling

The DFES concludes that EVs, heat pumps and planned development are projected to be the top three contributors to the growth in energy consumption.

Figure 2 shows the expected Electricity consumption in Best View Scenario

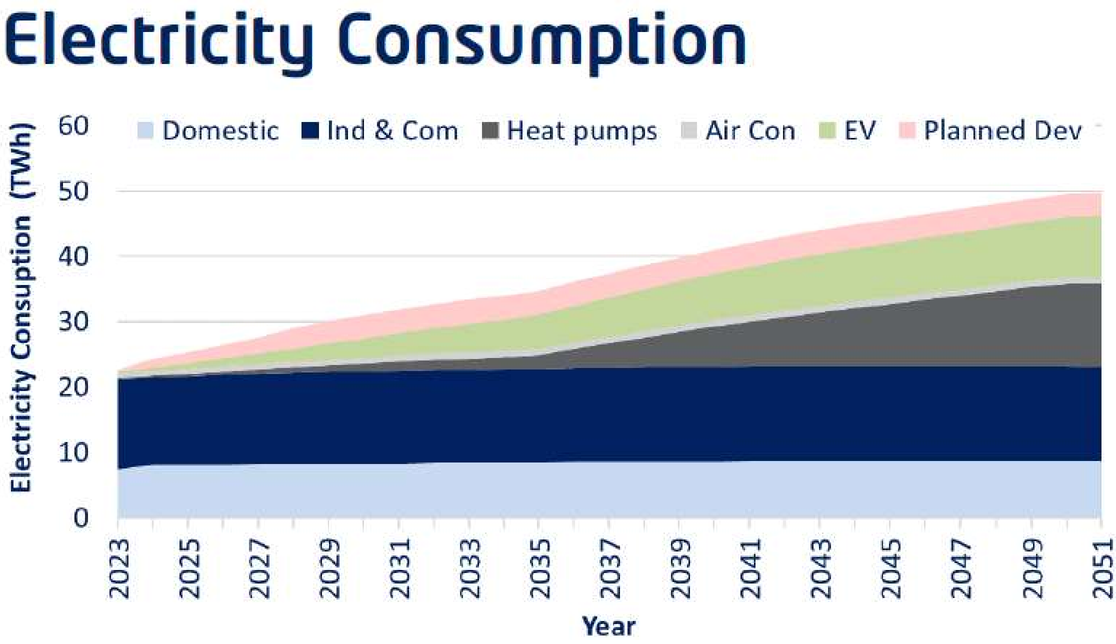


Figure 2: DFES Energy consumption

Air conditioning can be seen on the graph in figure 2 but is minimal in comparison with other contributors and doesn't show any significant growth over time.

The only other reference to air conditioning can be found in the scenario assumptions table in figure 3.

Scenario Assumptions in DFES 2023

	FALLING SHORT (FS)	SYSTEM TRANSFORMATION (ST)	BEST VIEW (BV)	CONSUMER TRANSFORMATION (CT)	LEADING THE WAY (LW)
Domestic Thermal Efficiency	L	M	H	H	H
Domestic Appliance Efficiency	L	M	M	M	H
Domestic Appliance Volumes	H	H	M	M	L
Non-domestic energy efficiency	L	M	M	H	H
Domestic Heat Pumps	L	M	H	H	EH
Non-Domestic Heat Pumps	L	M	H	H	EH
Electric Vehicles (Cars & Vans)	L	M	M	H	H
Smart EV Charging & V2G	L	M	M	H	H
Electric Heavy Duty Vehicles	L	L	M	H	EH
Air Conditioning	H	M	M	M	L
Demand Connections (HV and LV networks)	Lower Confidence	Historical Confidence**	L (access SCR impact)	M (access SCR impact)	H (access SCR impact)
Local Stakeholders Plans	Lower Confidence	Confidence Based on Project Ranking	Confidence Based on Project Ranking	Confidence Based on Project Ranking	Confidence Based on Project Ranking
Electrification of Industrial Processes	L	M	M	H	EH

Figure 3: Scenario assumptions

5 Potential Impact on current DFES Space Cooling assumptions

As it currently stands it could be assumed that the DFES has accounted for Space Cooling (SC), and its impact on the future energy scenarios is of minimal concern compared to other areas. However, the current Air Conditioning (AC) scenarios and assumptions that feed into this DFES are based on an assessment done in 2016(ref 2). This took a very high-level approach with limited data and based scenarios on historic growth and potentially very conservative AC penetration growth rates.

As the temperature in the UK is expected to rise due to climate change, there will be an increase in uncomfortably hot days which will prompt an increase in customer access to SC.

The work carried out by UCLC implemented a high-resolution approach, modelling overheating risk for each building and assigning cooling load to those buildings.

From this modelling work, it has been highlighted that the impact of SC could be significantly more than is currently accounted for, especially in domestic properties.

A comprehensive breakdown of how this was achieved and the results, can be found in the WP2 Report.

This is particularly significant as the domestic sector is currently expected to encounter a marginal decrease due to efficiency measures as high heat pump uptakes are combined with retrofits and other energy efficiency measures.

6 Approach to Exploring the Network Impact of Space Cooling

Building on the modelling results from WP2, WP3 explores the wider network impact SC might have on the distribution network under different scenarios. The approach taken to modelling the impact of SC on the network is outlined below:

- Identified 36 substations suitable for modelling fitted with advanced Low Voltage monitoring to establish baseline demand. Substations with a typical representation of domestic / non-domestic customers were targeted.

- Forecasted uptake of EV and HP from DFES and AC uptake from WP2 UCLC modelling results, using percentages of domestic and non-domestic buildings identified as overheating.

- Recorded HP and EV demand per 100 customers from DFES. Calculated average AC cooling demand per the number of customers from the modelled substations (158) using UCLC results.

- Developed scenarios - 100% cooling uptake, 50% cooling uptake, 100% cooling uptake with DR and 50% cooling uptake with DR. These scenarios consider the network impact if the cooling uptake is lower or if there is less participation in DR programmes.

- Using the forecasted uptake volumes and associated demand values the maximum demand at each substation was calculated, scaling down from primary level under each of the 4 scenarios up to 2050.

- Results were then analysed and compared to see impact SC has on the network sample area and to explore the potential benefits of implementing DR to manage constraints.

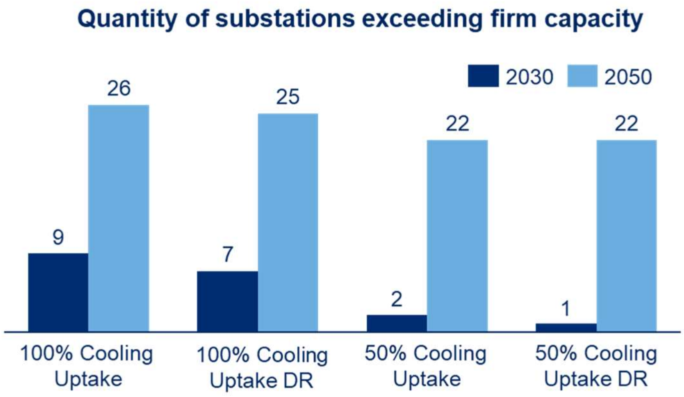
7 Key Findings from Network Impact Modelling

The modelling exercise compared forecasted uptake and associated demand values against the substation ratings, firstly with 100% cooling uptake (indicating all buildings within UCLC model which are showing as overheating would install SC) then secondly with DR applied (indicating customers would accept an increased SC set point during peak times thus lowering demand) this allowed the DR benefit to be calculated. The same exercise was then undertaken for 50% cooling uptake and 50% cooling uptake with DR applied. The results are as follows:

Quantity of substations exceeding capacity

- 100% Cooling uptake – 9 of 36 substations exceeded capacity by 2030 and 26 of 36 by 2050. Using DR indicated reinforcement on 2 substations could be deferred by 2030 and 1 by 2050.

- 50% Cooling uptake – 2 of 36 substations exceeded capacity by 2030 and 22 of 36 by 2050. Using DR indicated reinforcement on 1 substation could be deferred by 2030 and 0 by 2050.

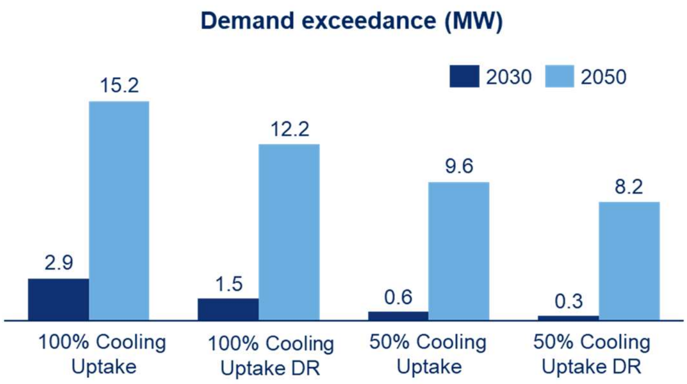


Due to high level of forecasted EV and HP uptake by 2050, the results show a lot of substations will require reinforcement without additional SC demand which has resulted in relatively low number of substations which could have reinforcement deferred by SC DR in 2050. For this reason, it is also beneficial to look at the level of demand which exceeds the substation ratings and compare this value against DR equivalent to understand SC DR potential.

Demand exceedance (MW)

- 100% Cooling uptake – 2.9MW by 2030 and 15.2MW by 2050, with DR applied 1.5MW by 2030 and 12.2MW by 2050 indicating there is DR potential of 1.4MW by 2030 and 3MW by 2050.

- 50% Cooling uptake – 0.6MW by 2030 and 9.6MW by 2050 with DR applied 0.3MW by 2030 and 8.2MW by 2050 indicating there is a DR potential of 0.3MW by 2030 and 1.4MW by 2050.



In the limited network sample size, the results indicate SC has the potential to have significant impact on the distribution network if adopted in large numbers. The results also show that DR could mitigate some of the SC impact if there is sufficient participation in DR programmes.

8 Recommendations for DFES

The findings from this Discovery Project have highlighted the potentially much greater impact on the Network as a result in the increased uptake and usage of SC.

Due to the small sample size of substations used for analysis in the modelling, more work is needed to verify and refine the findings so far before any changes to the DFES can be proposed.

This work would include modelling a greater sample size covering a more diverse range of property types, customers and geographical locations.

In additional to improving the model, work is needed to understand the diversity factor needed to be applied to SC load as this is an area which isn't fully understood at this stage.

In addition to this the project is also looking at the viability of using DR to manage this potential increase in load and prevent individual substations from becoming overloaded. Varying levels of DR could be applied different future energy scenarios.

References

1 - *DFES 2023*

https://www.enwl.co.uk/globalassets/get-connected/network-information/dfes/current/dfes-2023.pdf

2 - *Tyndall Centre, Air Conditioning Demand Assessment. 2016*