EAUC Energy Seminar - navigating barriers to energy cost control and storage

Warwick experience

Joel Cardinal

WARWICK

ENVIRONMENTAL SUSTAINABILITY

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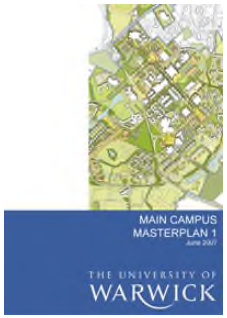
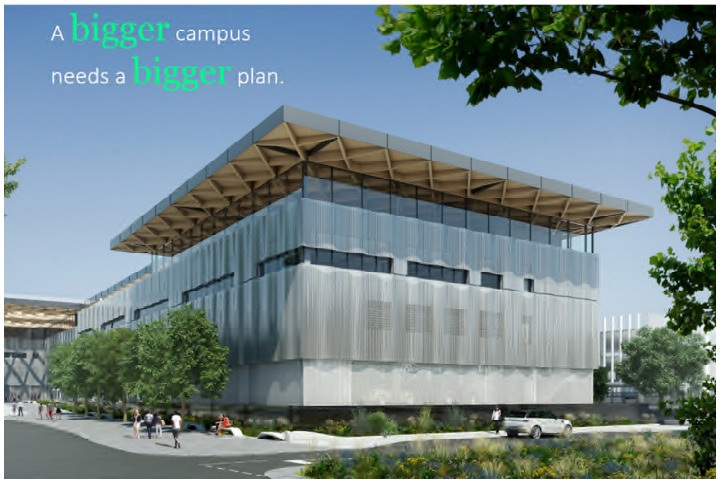
Agenda

- ✓ Unique heat Network Asset
- ✓ Sustainability Policy to 2020-30
- ✓ Efficiency and Innovation
- ✓ Further developments





University of Warwick Vision

- Globally connected leader
- High Quality teaching and research
- Sustainability at the core of everything
- Pioneer in knowledge transfer

"a living demonstration of the principles of environmental sustainability"

An international university

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Warwick is a globally connected University

"To make a real impact on global issues and deliver the **best research and teaching experience** for its staff and students it has chosen to form **close partnerships** with a select group of **research-heavy institutions** that exist in many locations, do research in many locations, and which produce students who see themselves as global citizens.

Such close and select partnerships can share research resources enhances the student experience and help serve a much wider community both nationally and Internationally. Warwick has also chosen to form partnerships, such as with **Monash University in Australia** and **CUSP in New York**, that are not based on geographical proximity or focused on a search for economies but has instead in each case sought partnerships between autonomous institutions that are academically excellent, share Warwick's organisational and academic ethos between and which help create a truly global network."

Our Energy Profile

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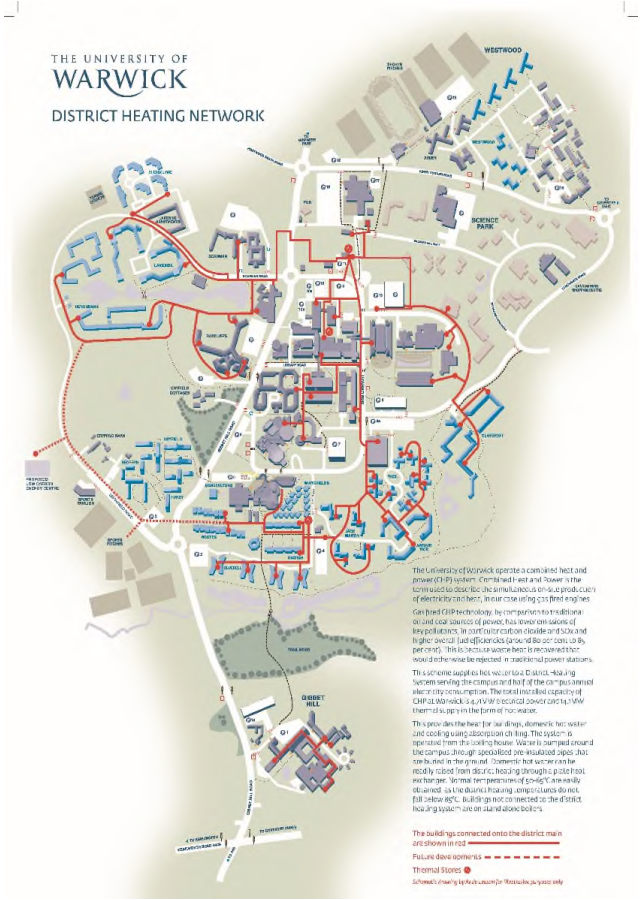
2013/14 main campus	Typical Annual Figures	UK household equivalent
Total Utilities Cost	£9.3m	7,300 homes (£1,272 pa)
Electricity Consumption	60,000,000 kWh (approx. 50% self generated)	15,000 homes (4,100 kwh pa)
Gas Consumption	150,000,000 kWh	10,000 homes (16,000 kwh pa)
CO_2 emissions	45,878 tonnes	8,600 homes (5.35 tCO2 pa)
Water Consumption	605,000 m^3	4,600 homes (360 litres per day)

Statistics references in Power Point file notes

Combined Heat and Power & District Heating

One of the large cogeneration schemes in the UK…

- Electricity, heat and cooling generation from 6 natural gas CHP's
- Heat distributed to 60% of buildings
- 19 km of Pipework
- 8.6MWe Electricity generation
- 1.2MWth absorption cooling
- Fully owned and operate installation
- Fully own and operate other networks (electrical distribution, controls, communication, water)



CHP and District Heating

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- Overall benefit
  - Reduce University carbon emissions by 10%

    CHP & District save in excess 5,000 tCO2pa

    Thermal stores & controls contribution saves circa 700 tCO2
- 6 CHP engines across the campus

2off Cryfield engines
(2,700 bhp each)

3off Boiler House engines
(1,900 bhp each)

1off Gibbet Hill engine
(550 bhp)

CHP and District Heating

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- 4off absorption chillers (reduces carbon emissions by making chilled water from available heat)
  - 4 district cooling networks around campus
  - 1.2MWth
  - Increase summer heat load and reduce electrical consumption
- 4off 5MWth boilers (high efficiency boilers)
- 500m^3 Thermal storage (daily storage support peak time demand and avoid firing boilers)
  - 300 tonnes at energy centres
  - New buildings have local storage
  - ~10MWh capacity
- Advanced Controls policy
  - Continuous modulation to optimise carbon emissions
  - Maximise thermal stores cycling
  - 4 hours CHP load forecast
- Maintenance policy
  - Dynamic monitoring to avoid heat wastage

Our Energy and Carbon Strategy

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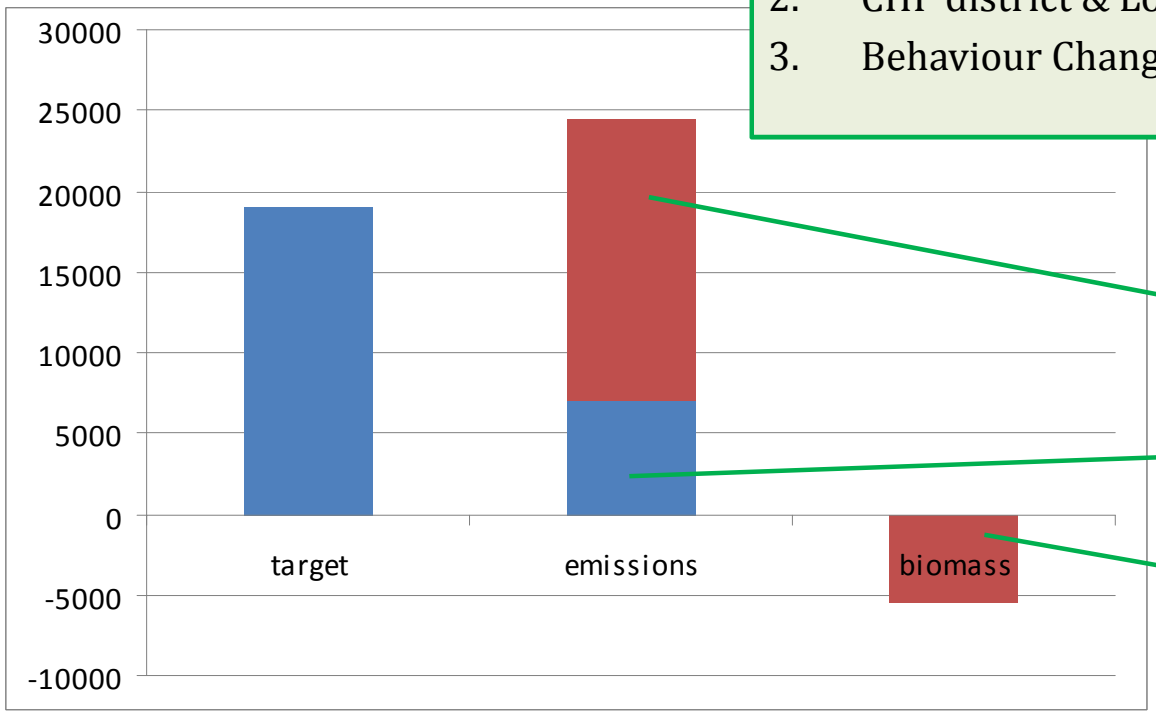
1. Energy conservation & efficiency
2. CHP district & Low carbon generation
3. Behaviour Change



Emissions from "improved" current Estates

Emissions from new Estates

"Low Carbon" fuelled CHP

Predicted 2020 CO2e emissions for Planned campus expansion as per Master Plan & Strategy 2007

CHP & District Heating control improvements

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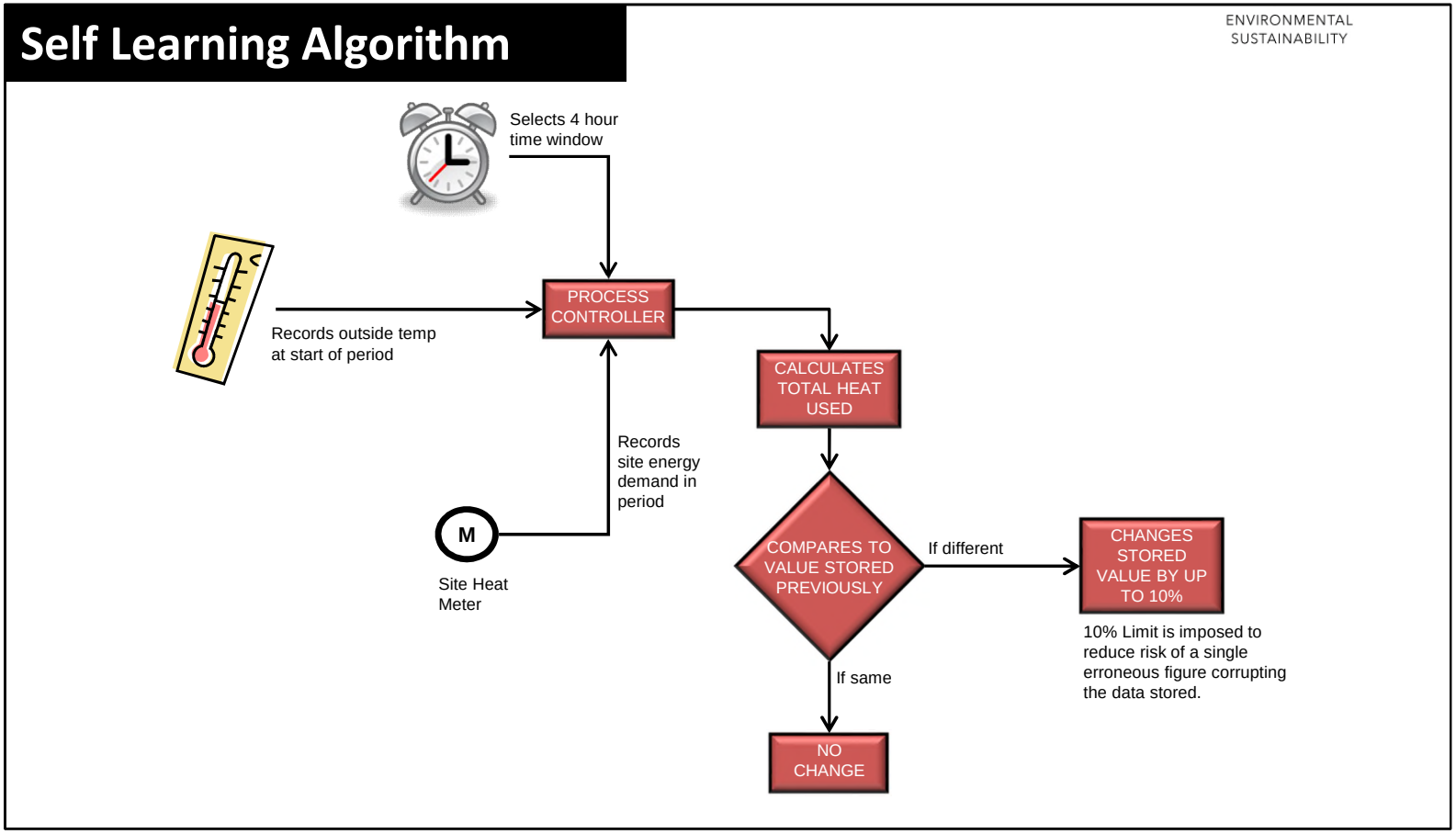
- Innovative project delivered with University suppliers (Honeywell and Cpwp)
- Manual scheduling is replaced by predictive controls
- Small investment (£20k) in development costs
- Significant benefits
  - Additional 790tCO2 per annum saving
  - Operational benefits (reduced manual intervention)

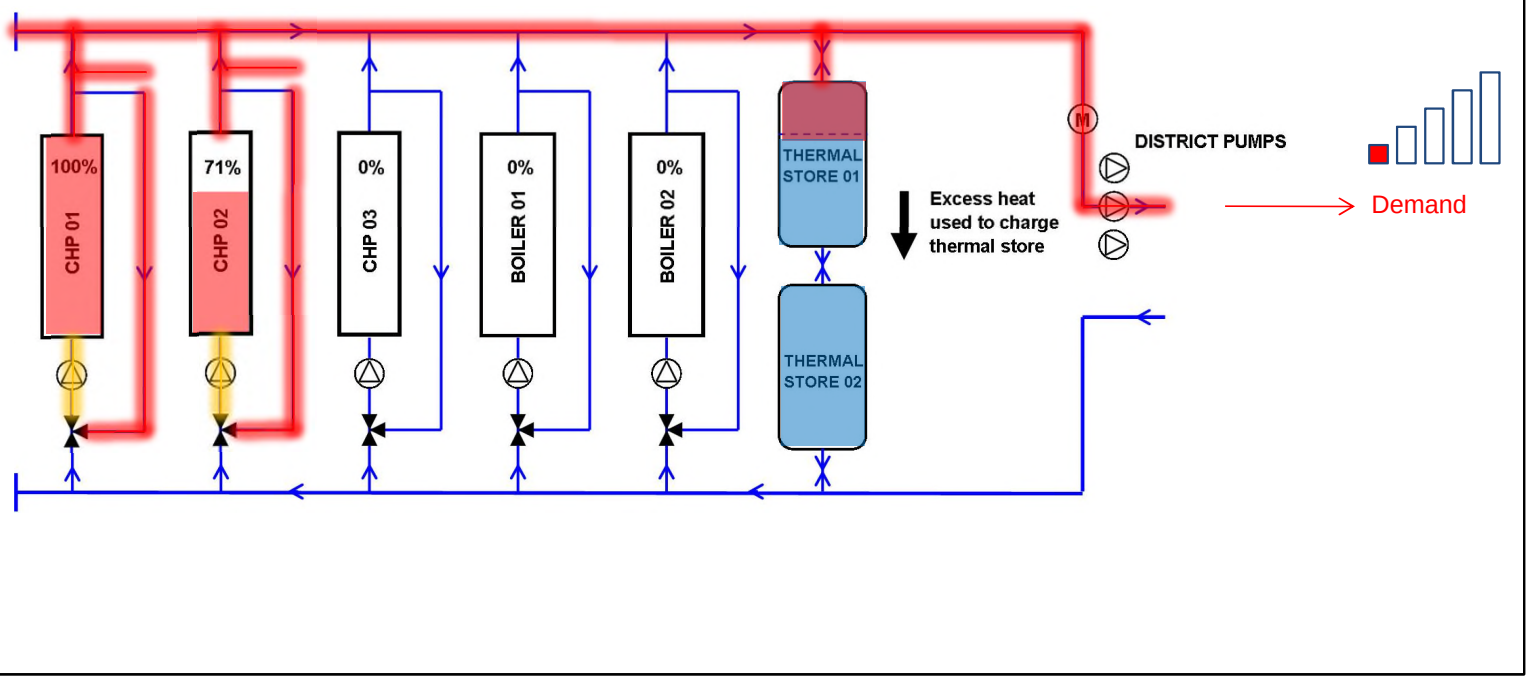
CHP & District Heating control improvements

Self Learning Algorithm



How does the system save Carbon/Energy

Low Demand



Can we improve the CHP modulation systems ?

Work in Progress

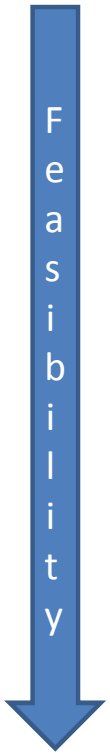
- Optimise distribution
- Heating 24/7 to match heat delivery with heat demand?
- Include "floating" buildings to controls
- Include new Thermal Stores in controls
- Maintenance
  - Fix short circuits to lower DH return temperature
  - Intelligent valves to control flow delivery to buildings
  - Dynamic knowledge of district load / flow

Needed

Needed

Targeted improvements CHP systems

Possible future works



- Expand network to create additional heat load
  - Be able to operate as an island
  - Resilience in case of loss of gas
- Optimise savings
  - Revenue from export at Grid peak time?
  - Organic Rankine Cycle
- Cleverer prediction table
  - Account for campus activity
- Explore electrical storage to heat storage
- Explore interseasonal heat storage (summer-winter)

Inter-seasonal Heat Storage

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- Is an industry concern to support renewable energies intermittence.
- It is estimated that the amount of waste heat per year is equivalent to the UK annual energy consumption for heating (source: Dave Elliot Open University)
- Government papers are calling for district and CHP to supplement building insulation to deliver CO2 savings.
  - DECC 2050 pathways
  - Danish and UK examples of district large heat stores fed by CHP and solar energy
- University = Significant prospect for reduction of CO2 emissions and utilities costs

Feasibility

	Heat stored	£ saved	tCO2 saved
Follow heat profile	5,000MWh	£160k	170 tCO2
Maximise (maintain 24/7 operation in summer)	11,600MWh	£450k	2,400 tCO2

Inter-seasonal Heat Storage

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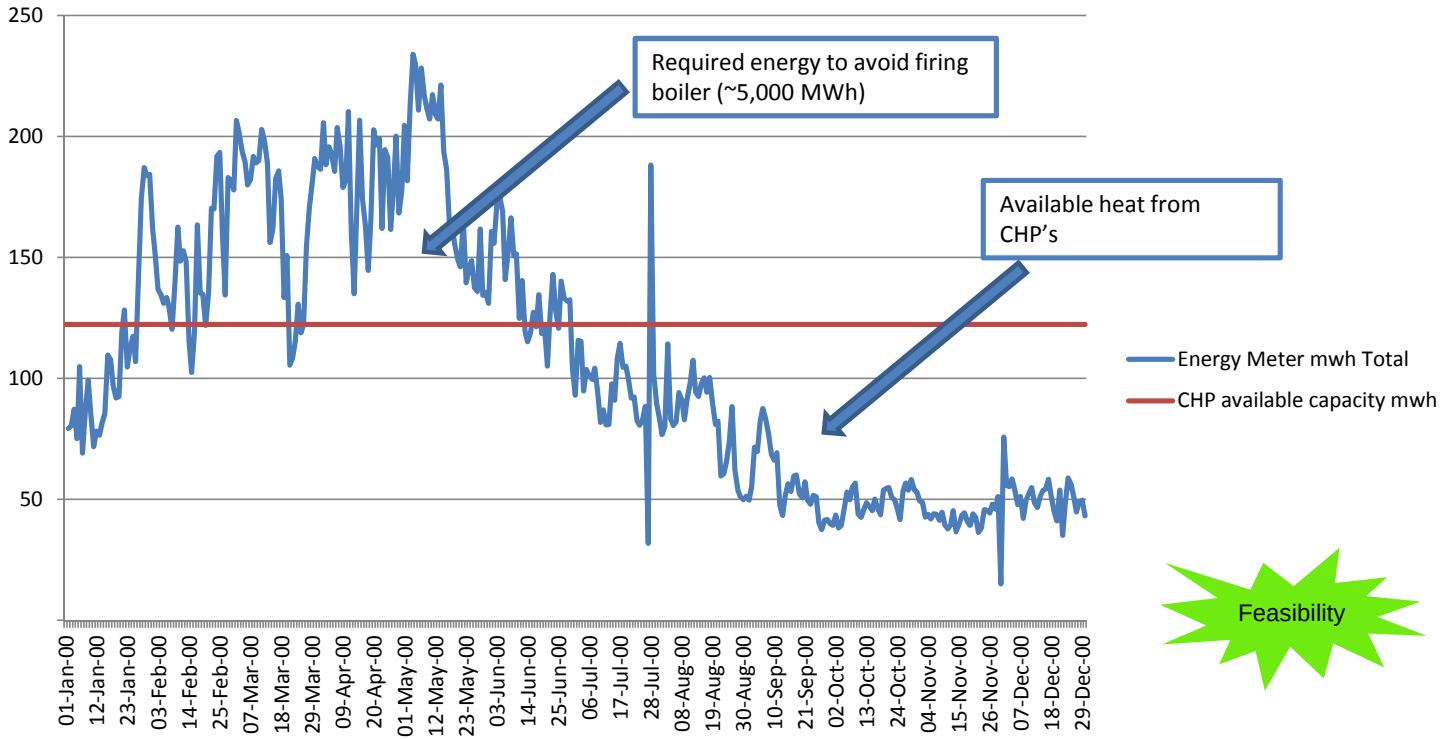
- Load profile & Opportunities



Feasibility

Inter-seasonal Heat Storage

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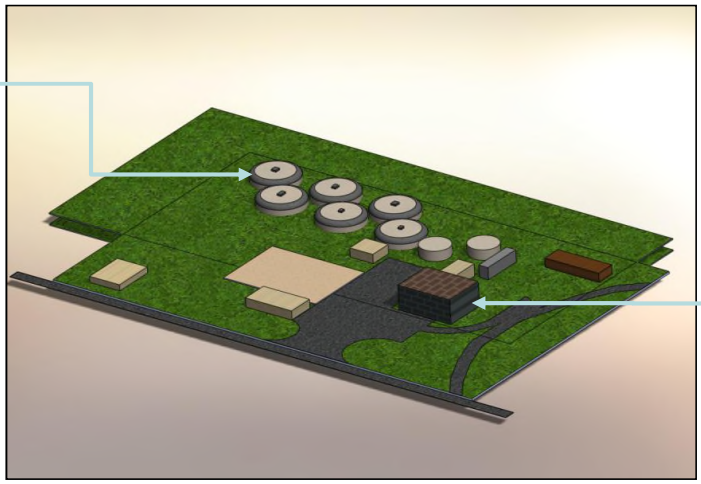
Feasibility

- The excess heat from CHP exhaust gases during summer is stored as latent heat in a phase change material (PCM)
- This thermal energy storage system is then used over the winter months to heat water and replace the need for boilers

PCM Stores
(6 storage tanks,
10m x 9m radius,
semi-submerged)



Boiler House

Heat Network Innovation Project

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Department of Energy & Climate Change

Research feasibility

- ✓ Warwick drive for efficiency is applied to heating-cooling network design and operation.
- ✓ DECC Heat Network Innovation was opportunity to explore new options
  - ? Can 2010 BEMS controls be improved
  - ? Can we improve thermal energy storage
  - ? Can we make more electricity from waste heat

EBRI European Bioenergy Research Institute
Aston University Birmingham
couchperrywilkes engineering change
imagination at work

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