The Future of Energy in Warwick's Masterplan

14th November 2018  Joel Cardinal
Agenda

We are a small town – Efficient growth to date

Context - UK Climate Change commitment

Warwick Energy Journey

Masterplan – Need for paradigm shift

Efficiency - Central to Approach & Innovation
University of Warwick –
An Overview

- Ranked 7th overall in the UK (The Times, 2017)
- Four departments ranked as the leading in the country.
- 87% of our research is ‘world-leading’ or ‘internationally excellent’
- 19 departments in the top 10 in the UK
- WMG (Warwick Manufacturing Group)
- WBS – Global MBA’s
- Sciences Park
- Conferences
Our Students

• One of the largest University campus in Europe.
• 25,615 students
• 6,294 academics, researchers and staff
• 7,000 accommodation rooms
Main Campus

“a 24/7/365 town of 30,000 people”

- 560,000m² built
- 290 Hectares
- 7,000 students rooms
- More than 150 buildings
- 3 conference centres
- 2 Sport centres
- Retail / cafes / restaurants
- Arts Centre
- Offices & teaching buildings
- Industrial & Research buildings
- 19km heating/cooling network
- Self-generate at least 50% of heat and power needs

Our Wellesbourne Campus

- 215 Hectares of Research & farming
- Research and Business park
## Our Energy Profile

<table>
<thead>
<tr>
<th>2015/16 main campus</th>
<th>Typical Annual Figures</th>
<th>UK Household Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Utilities Cost</strong></td>
<td>£8.3m</td>
<td>6,500 homes (£1,272 pa)</td>
</tr>
<tr>
<td><strong>Electricity Consumption</strong></td>
<td>72 GWh (50%+ self generated)</td>
<td>17,500 homes (4,100 kwh pa)</td>
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<tr>
<td><strong>Gas Consumption</strong></td>
<td>161 GWh</td>
<td>10,000 homes (16,000 kwh pa)</td>
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<tr>
<td><strong>CO₂ emissions</strong></td>
<td>40,421 tonnes</td>
<td>7,476 homes (5.35 tCO₂ pa)</td>
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<tr>
<td><strong>Water Consumption</strong></td>
<td>589,000m³ (589 million litres)</td>
<td>4,500 homes (360 litres per day)</td>
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</table>
What have we achieved?
3 steps Energy & Carbon Strategy

- Meet carbon emissions targets
- Reduce UoW Operating costs
- Increase Resilience

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

Predicted 2020 CO2e emissions for Planned campus expansion as per Master Plan & Strategy 2007
Low carbon economy, a sound business case at Warwick

Latest water project saves enough water to fill 16 swimming pools annually

In excess of 1 acre of PV installations by 2018, enough to power 85 homes.
Successful University Growth

- University Buildings are 20-30% better than Buildings Regulation
- We continuously work on comfort, efficiency and performance

Breeam
Excellent
EPC-A
DEC – Energy in use
Air tightness
CO₂e Emissions Improvement

Efficiency: Carbon emitted per £ of income

In the graph below you can see how the carbon efficiency of the University has dramatically improved over recent years. This trend, which we aim to continue, has seen our efficiency almost double since 2005/6.

-44% Emissions per £1,000 income

We generate 60% of our electricity and hot water on campus through an efficient Combined Heating and Power system.

We opened the Cryfield Energy Centre in 2014 to provide more super-efficient combined heating and power for campus.

Making sure all the new buildings we add to campus are much more efficient than the older ones they’re replacing.

We worked to add more renewable energy sources to campus.

We worked to cut our Water use - water cleaning produces emissions too.

Our staff and students have made a real effort to think in a more sustainable way.
2017/18 Emissions Increase

SCOPE 1 AND 2 CARBON EMISSIONS BY SOURCE

+3.6% in 2017/18
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From carbon emissions to SDG
Is it confusing enough?

GLOBAL WARMING OF 1.5 °C
Summary for Policymakers
INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Cumulative emissions of CO₂ and future non-CO₂ radiative forcing determine the probability of limiting warming to 1.5°C

- Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

Global warming relative to 1850-1899 (°C)

- Likely range of modeled responses to stylized pathways
  - Global CO₂ emissions reach zero in 2035 while non-CO₂ radiative forcing is reduced after 2035 (grey in h: c & d)
  - Faster CO₂ reductions (blue in h: c & d) result in a higher probability of limiting warming to 1.5°C
  - No reduction of non-CO₂ radiative forcing (purple in h: c & d) results in a lower probability of limiting warming to 1.5°C

University carbon emissions from procurement and construction

University carbon emissions from energy consumption

Scope of Energy Masterplan

NEED FOR EFFICIENCY

BP recognizes that the existing trend of increasing greenhouse gas emissions worldwide is not consistent with limiting the global average temperature rise to 2°C or lower.

A complex issue
BP believes global action on climate change is needed. It’s a complex issue and all aspects of the debate should be considered in their totality.

There are multiple actors and actions

Emissions to rise through continued fossil fuel use

20%
higher projected CO₂ emissions from fossil fuels by 2035

All fossil fuels are not equal

There is a variety of oil and gas users

80-90%
of CO₂ emissions from oil and gas products are from their use by consumers

IEA report Energy Technology Perspectives 2017 (zero by 2060) = http://www.iea.org/etp/
We need Collaboration...

Carbon use controlled by Estates

40%

60%

Carbon use controlled by everyone else
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Watch your wallet... to save carbon
Genesis

• University granted Royal charter in 1964
CHP journey

• Main campus 2000-05
  – Maintenance and operation issues and insurance inspection on 9 off HPHW calorifiers
  – Decision to change to LPHW Low Temperature + variable volume (short payback)

• By 2005
  – 3 off 1.4MWe gas CHP
  – 2 off 5Mw boilers
CHP and District Heating

- 6 CHP engines across the campus
- Self-generation capacity = 8.6MWe + 9.5MWth
- 15MWth back-up boilers
- 4 absorption cooling networks around campus = 1.2MWth

2off Cryfield engines
(2,700 bhp each)

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

1off Gibbet Hill engine
(550 bhp)
CHP journey

• Gibbet Hill campus 1999/2000
  – Proliferation of split A/C + high energy and high Maintenance issues
  – Justification by bringing future maintenance programs
  – Innovation grant for Tri-generation (£50k)
  – Develop “above ground” heat network.
  – Optimise by connecting heat / cooling loads

– Current =400kwe + 500kwth + 900kw boiler (limitation due planning as energy centre is embedded in building)
Diversity & Energy Storage

- **4off absorption chillers** *(reduces carbon emissions by making chilled water from available heat)*
  - Increase summer heat load and reduce electrical consumption

- **Back up boilers** *(high efficiency boilers)*

- **500m³ Thermal storage** *(daily storage support peak time demand and avoid firing boilers)*

- **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
Heat Network Efficiency >10%

Self Learning Algorithm

- Selects 4 hour time window
- Records outside tems at start of period

PROCESS CONTROLLER

- Calculates total heat used
- Compares to value stored previously

- If same: No change
- If different: Changes stored value by up to 10%

Site Heat Meter

Graph Change in Profiles to Date

Medium Demand

- 10:00 9°C
- Thermal Stores reduces waste heat and increase overall energy centre efficiency
- Annual saving ~£97,000 ~770 tCO2
Heat Network Efficiency >10%

• Optimise controls
  – Increase district flow / return temperatures differential
  – Reduce CHP heat dump (clean heat exchangers)
  – Boilers management (Control firing, “boilers inhibit” to avoid heat waste)

• Optimise heat distribution
  – Fix short circuits to lower DH return temperature
  – Set Samson valves to control delivery
  – Adequate pressure reference points

• Play tune with capacity
  – Heating 24/7 to match heat delivery with heat demand?
  – Include "floating" buildings to controls
  – Include new Thermal Stores in controls
Inter-seasonal Heat Storage
(2009 Students project)

- 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

Phase Change Material
(6 storage tanks, 10m x 9m radius, semi-submerged)
Combined Heat and Power & District Heating

One of the largest cogeneration schemes 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)
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Strategy - Excellence with Purpose

By 2030, Warwick will be one of the world's exceptional universities, helping to transform our region, country and world for the collective good.

Strategic Direction

In this strategy, we imagine how the University of Warwick might be in 2030: how we will be excellent in everything we do and how our excellence will be channelled into a renewed purpose and impact.

Read more...

Warwick's Core Purposes

We begin with our aspirations in our core purposes of:

- Research
- Education

Our Four Strategic Priorities

Our Research and Education will be underpinned by four key strategic priorities:

1. Innovation
2. Inclusion
3. Regional Leadership
4. Internationalisation

Warwick in 2030

Our University will be larger in 2030 than now, both in our student population and our research. That growth will be sustainable and will never compromise on quality. Our growth will be particularly in science, technology, engineering and mathematics, but will also build on our other existing strengths across all our disciplines.

Read more...

Include Sustainability
In 2030, our University will be larger than now, both in our student population and our research. That growth will be sustainable and will never compromise on quality.

Priorities

- Develop sustainable transport, energy and a green campus to enhance the environmental sustainability of our University
- Embed sustainable development principles across our strategies and delivery plans, to include a focus on our financial security.
Masterplan – UK grid is decarbonising

Electrification of Heat

<table>
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<tr>
<th>Period</th>
<th>Carbon Intensity (gCO₂e/kWh)</th>
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<tbody>
<tr>
<td>Part L 2013</td>
<td>519</td>
</tr>
<tr>
<td>Actual Year 2017</td>
<td>275</td>
</tr>
<tr>
<td>Predicted Year 2023</td>
<td>175</td>
</tr>
<tr>
<td>Predicted Year 2030</td>
<td>110</td>
</tr>
<tr>
<td>Predicted Year 2035</td>
<td>65</td>
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Heat delivery
Natural gas powered CHP require model shift
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Zero Carbon Strategy from Energy

Life Cycle Cost of Zero Carbon from Energy

3 steps
- Optimise consumptions
- Plan suitable infrastructure
- Procure supply
Energy Masterplan Strategy

**Supply**
- Cryfield Energy Centre
- Main campus Boiler House
- Heating & Cooling Network
  - Convergence via smart controls
  - Electrical Network
- Dual Fuel
- Biomass Biomethane
- Solar
- Battery Storage
- Thermal Storage
- Vehicle to Grid

**Demand**
- Behavioural Science
- Vehicles
- Estates 52 Electric vehicles by end of 2018

**Resilience**
- Available on campus
- Required technology
- 2 off 100,000 gallons Tanks
- Wellesbourne
- Main Campus

**Flexibility**
Energy System Master Plan

Long term vision (2030-50)
- heat network + heat pump
- Very efficient buildings + Smart controls
- Renewable energy + Energy storage
- Electrification of transport

Transition period to be defined (2018-30)
- Better buildings + Better controls + Soft landing
- Reduce operating temperature
- CHP + More renewables
- Progress electrification of transport
Options Modelling

Energy Demand Breakdown

Site Energy Demand by Element

Electricity Consumption

Present
- Equipment: 34.5%
- Lighting: 24.0%
- Auxiliary: 37.4%
- Cooling: 4.1%
- EV Charging: 0.1%

2030
- Equipment: 30.8%
- Lighting: 35.7%
- Auxiliary: 7.1%
- Cooling: 9.0%
- Concurrent: 4.3%
- Heating and DHW: 35.7%
Options Modelling – 24 scenarios

Impact of EV

For those who want the technical detail

[Graphs and data tables related to heating and cooling demand, EV charger usage, and network load management are shown.]
Options Modelling – Land Requirement

Renewable Electricity

- 200 Acres Boreholes
  - 100 On Campus
  - 100 to South

- 100 to 210 Acres of PV

- 6 Wind Turbines

Conclusion

6 tests for Warwick Energy system scenario

1. Affordability test
2. Technical test (can secure zero carbon)
3. Resilience (can protect against utilities failure)
4. Flexibility (can adapt to university growth)
5. Disruption during build
6. Innovation (support impact / reputation)
Global Approach to Sustainability

“In the end, we will protect only what we love. We will love only what we understand. We will understand only what we are taught.”

Baba Dioum, Senegalese poet and naturalist

Come and join us.
Your ideas welcome.
Research and industrial partnerships.