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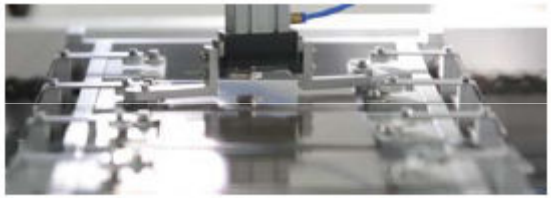

Alternative energy products for global markets

Fuel cells

Bob Flint, 17th March 2010

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What are fuel cells?

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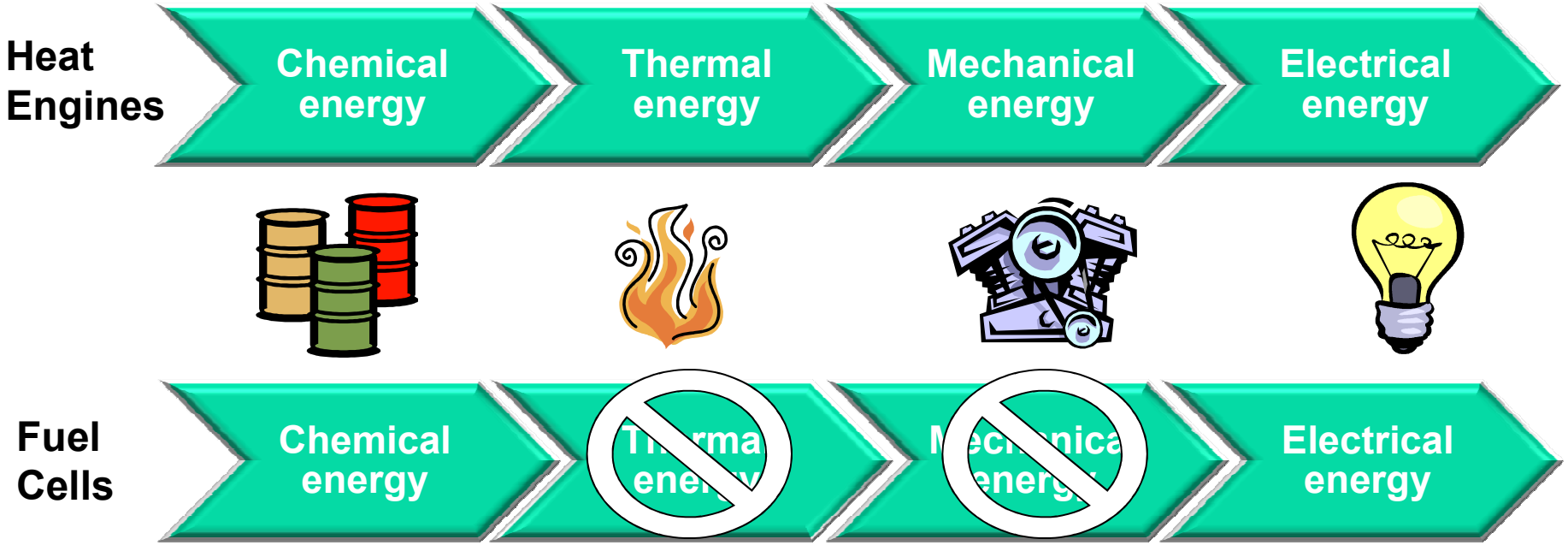
Fuel cells are ‘electrochemical engines’ that generate electricity & heat

- Environmentally friendly technology
- Operate on widely available fuel and air
- Quiet, efficient, solid state reaction
- Near-zero NOx, SOx and CO



Example fuel cell technologies

Low Temperature (<140˚C) PEM FC	Intermediate Temperature (500-600˚C) IT-SOFC	High Temperature (750-1000˚C) SOFC

Ideally suited to mass market residential scale distributed generation:

- Compact, lightweight, easy-to-fit products
- Compatible with today's + tomorrow's fuels
- Flexible generation capacity
- Designed for mass manufacture

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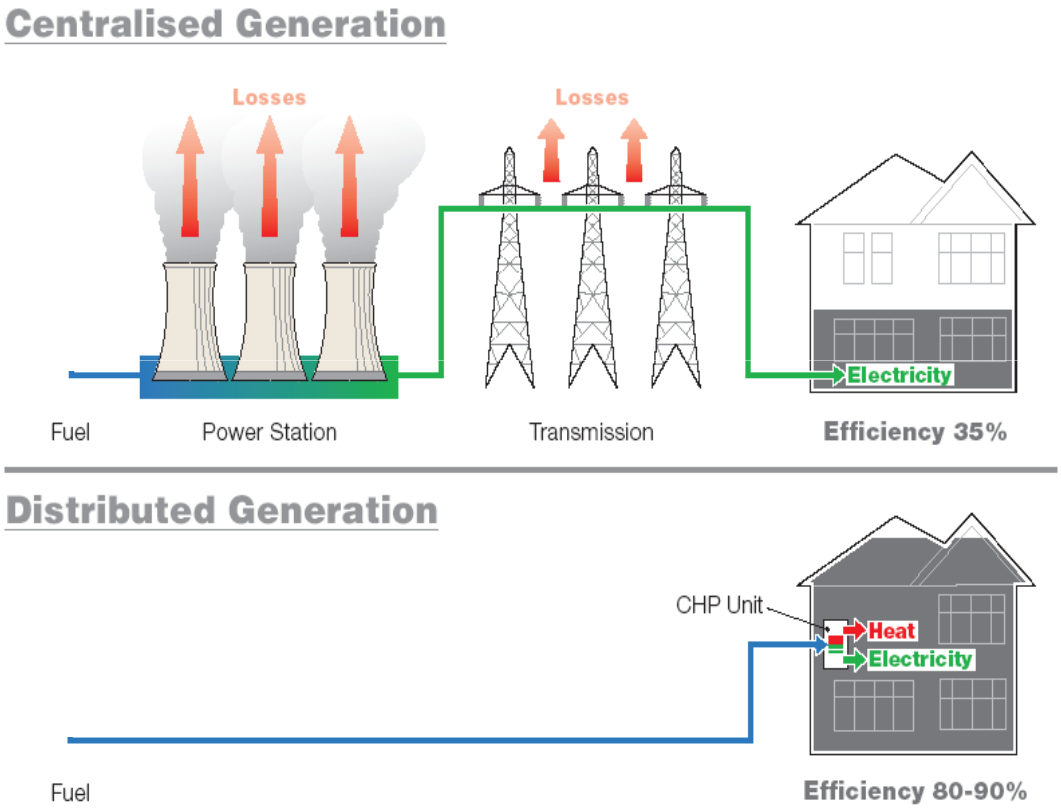
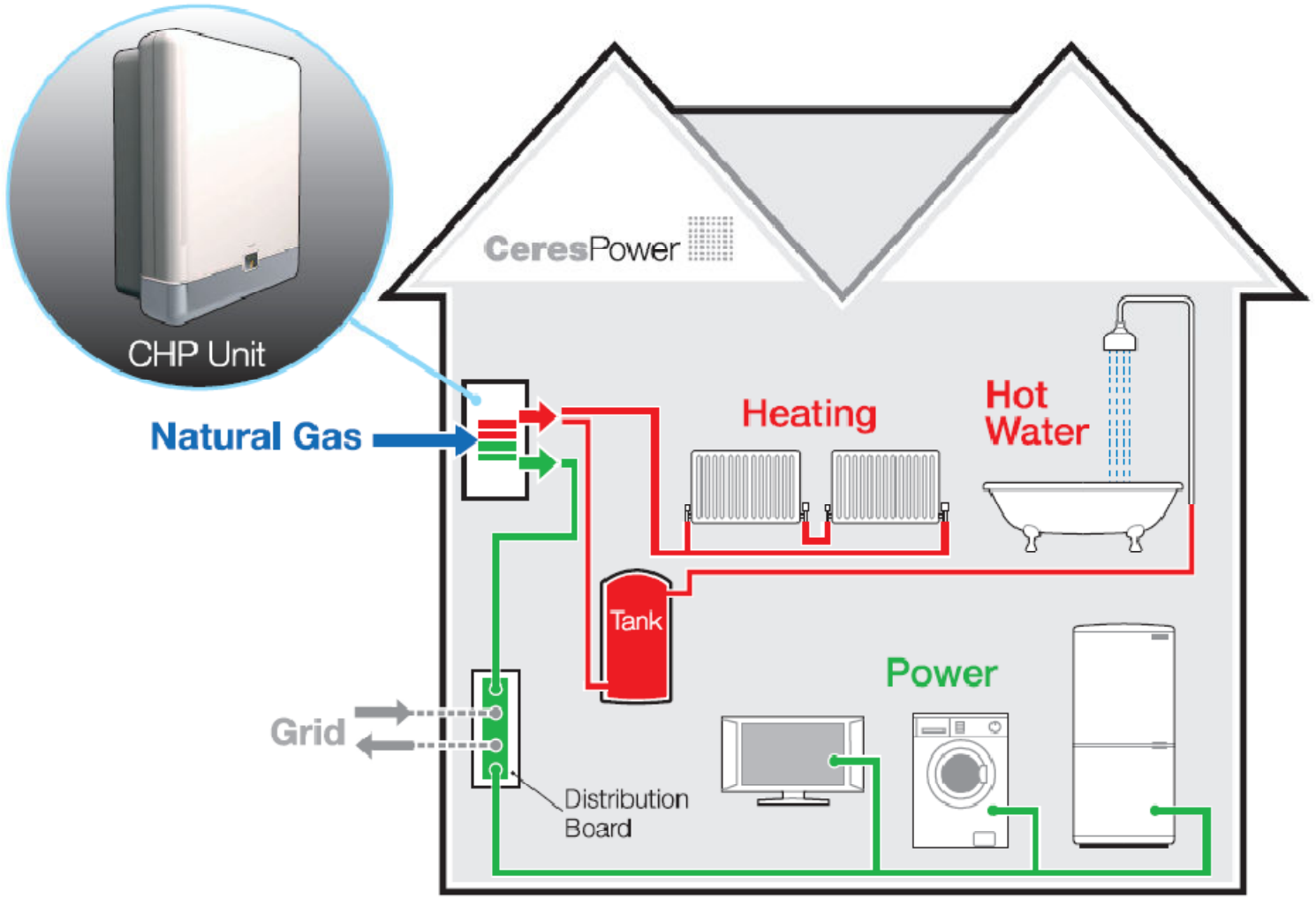
Fuel cell distributed generation

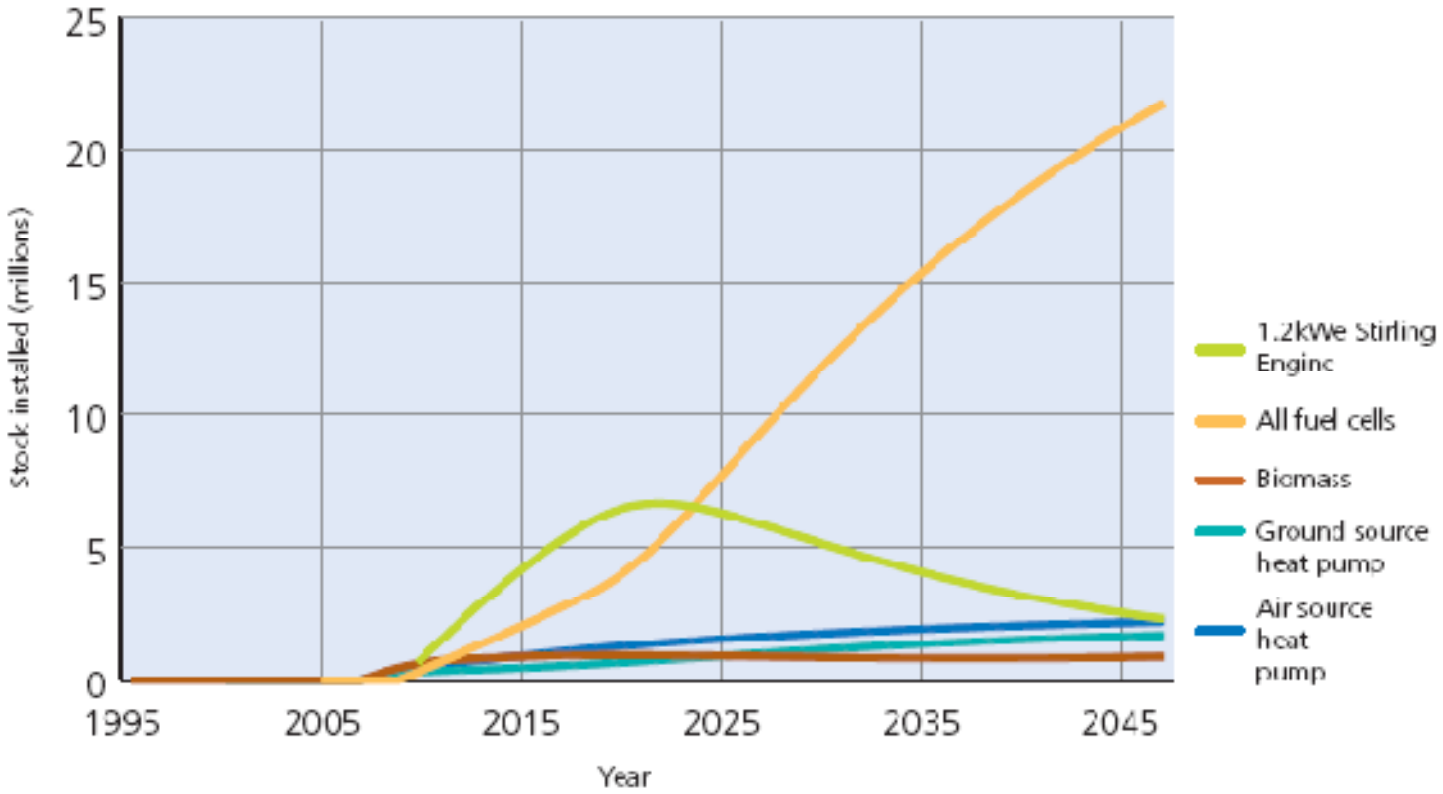
- Distributed Generation (DG): generate power at point of use, in the home
- Use a highly efficient process to reduce generating, transmission and distribution losses
- Capture heat output to drive further savings
- Package into a wall mountable consumer product
- A generation asset and demand reduction device



Fuel cell microCHP in the home



UK mass market potential



Source: Energy Saving Trust 2007 (study sponsored by UK government)

"Over 6M fuel cell CHP units installed by 2020 (30% of the market…)"

2008 Element Energy Report for BERR

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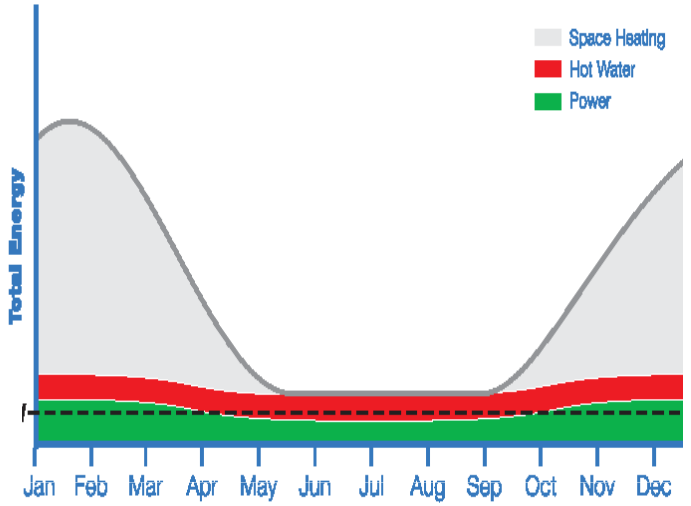
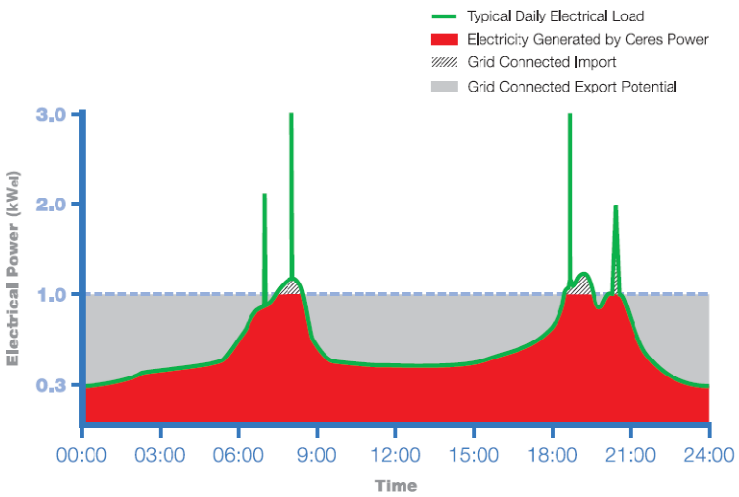
Beneficial technology characteristics

- Low heat to power ratio:
  - Heat captured for use within home
  - Enables year round operation, with low heat output matched to hot water requirement
- Load following & cycling capability:
  - Delivery of high value electricity during periods of peak demand
- Support for grid requirements:
  - Capable of turning on / off as required
  - Capable of exporting if required (e.g. via smart meter time-of-day tariff incentives)





Predicted carbon savings

- **Independent confirmation by Oxera**
  - Macro economic consultancy specialising in energy sector
  - Model of actual UK energy system including individual power plants (used by industry & Government)
- **Oxera confirmed carbon savings potential for example product (Ceres CHP) based on**
  - Predicted decarbonisation of grid (incl. large-scale deployment of renewables and nuclear)
  - Likely response of central generation to mass deployment of fuel cell microCHP
  - Resultant likely CO_2 savings (taking into account current and projected 'merit order')
- **Annual CO_2 savings of 1 to 1.5 tonnes p.a. up to 2020**
  - Relative to high efficiency condensing boiler and grid-supplied electricity
  - Based on actual power plants displaced in the merit order
- **Potential for significant additional benefits to UK energy system**
  - Reduces peak demand and generation investment requirements
  - Reduces capex requirements for grid network

Persistent carbon savings even with a decarbonised grid

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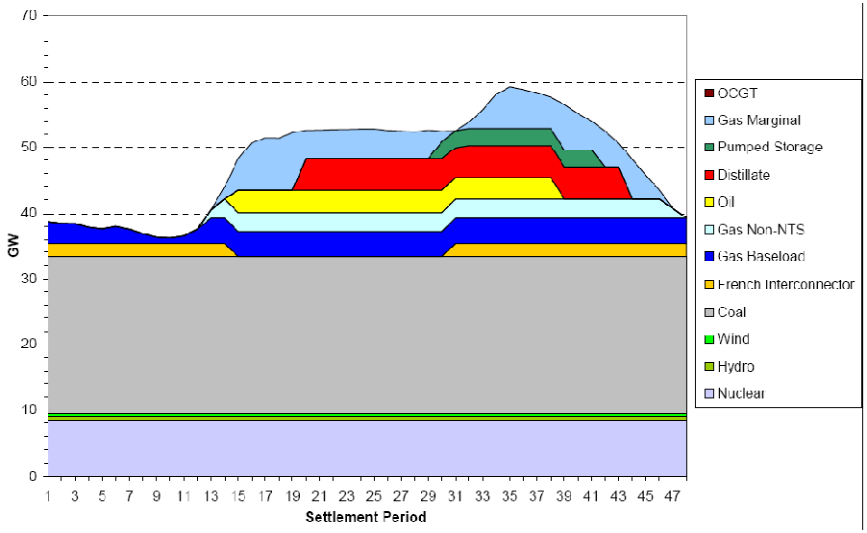
Fuel cell CHP reduces demand for central fossil fuelled generation, without displacing renewables or nuclear. Hence the CO_2 benefits of fuel cell CHP are additive to those from other technologies, and persist even as the average CO_2 intensity of the grid decreases.



Prediction by National Grid of a likely merit order on cold winter weekday in the winter of 2009/10.

- The CO_2 savings from fuel cell CHP are determined by the generating plant it displaces
- Which plant gets displaced is determined by the 'merit order'
- The position of generating plant in the merit order is determined by its marginal cost of generation
- Demand reduction by fuel cell CHP reduces the operation of 'marginal plant' i.e. fossil stations

Benefits of fuel cell microCHP

1. Cost effective CO_2 reduction for a difficult sector
   - *Retrofit of existing homes*

2. A major potential impact on CO_2 reduction by 2020
   - *Can be quickly deployed, compatible with majority of UK homes*

3. Persistent CO_2 savings even as the grid decarbonises
   - *Displaces peaking / mid-merit fossil plant*

4. Compatible with other carbon reduction measures
   - *E.g. nuclear, renewables*

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