Scenarios for Micro-CHP as Residential Building Insulation Improves

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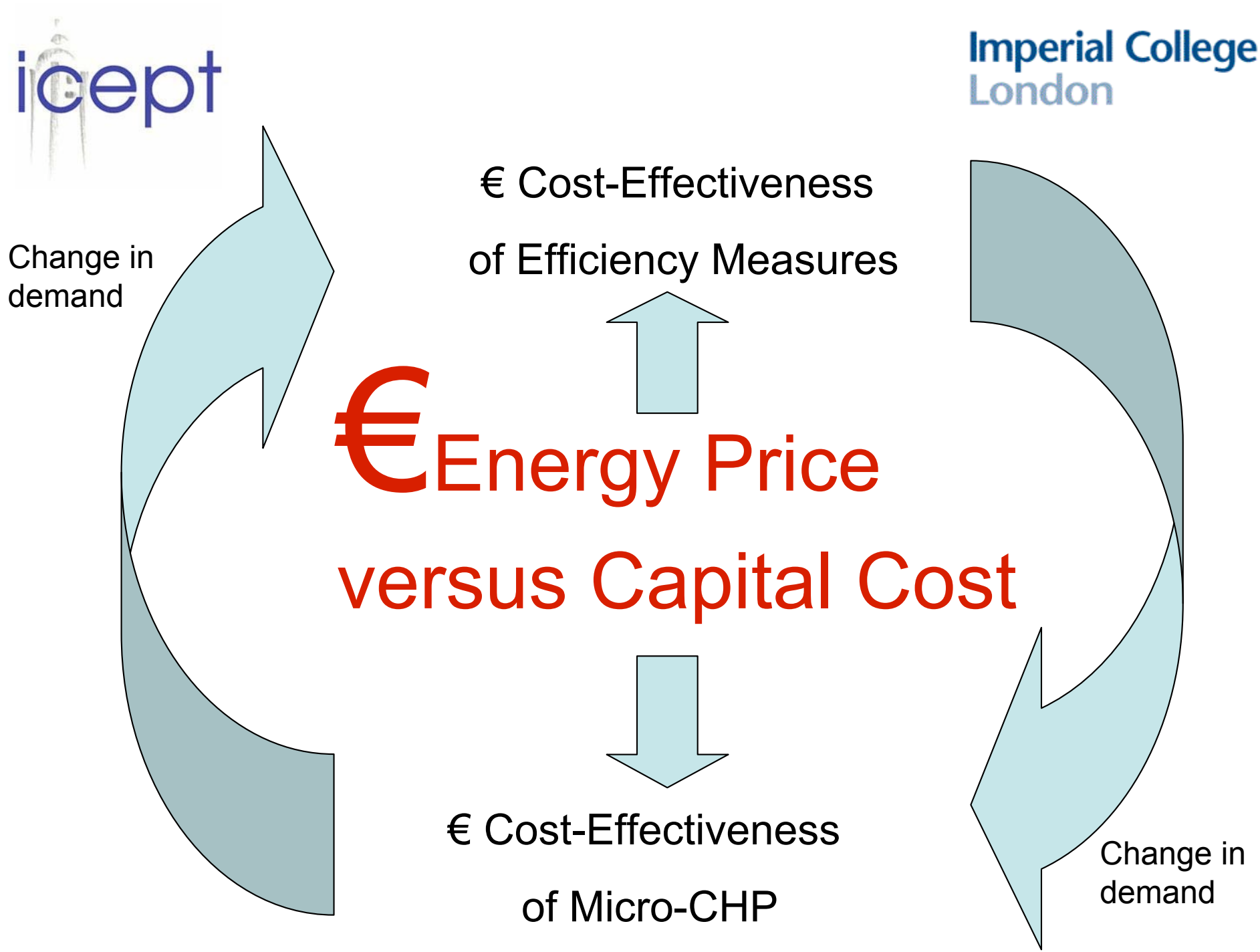
Competing Options?

- Energy Efficiency
  - Energy Efficiency Green Paper, through to recent IPCC Mitigation report.
  - Energy End Use Efficiency and Energy Services Directive
  - Energy Performance of Buildings Directive
  - Energy Efficiency Commitment (EEC) in the UK
  - EEC becomes Carbon Emission Reduction Target (CERT) for 2008-2011 Period.

- Micro-CHP
  - Rapid technology development
  - Possible grant support schemes under Low Carbon Buildings Programme
  - Possible inclusion in new CERT programme


icept
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€ Cost-Effectiveness of Efficiency Measures
Change in demand
€Energy Price versus Capital Cost
€ Cost-Effectiveness of Micro-CHP
Change in demand

Improving Insulation

- Change in Minimum Building Standards

Year	Roof U-Value (W/m^2K)	Wall U-Value (W/m^2K)	Window U-Value (W/m^2K)	Floor U-Value (W/m^2K)
1965	1.42	1.7	-	-
1976	0.6	1.0	-	-
1982	0.35	0.6	-	-
1990	0.25	0.45	-	0.45
1994	0.2	0.45	3.0	0.35
2002	0.16	0.35	2.0-2.2	0.25

Regulated Minimum U-Values for New Buildings in Britain

- Refurbishment:
  - Loft Insulation +90%
  - Cavity Wall Insulation ~40%
  - New glazing must be high quality

“Comfort taking” in the past but less in the future?

- Since 1970, average internal temperature changed from 12.6 to 18.8ºC.
- “Ultimate” comfort level of 21ºC, beyond which most people would not want to go?
- Therefore, further insulation may result in lower average space heating consumption?

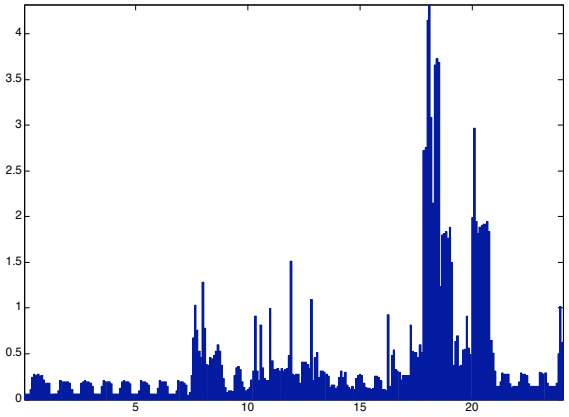
Basic Thermal Model

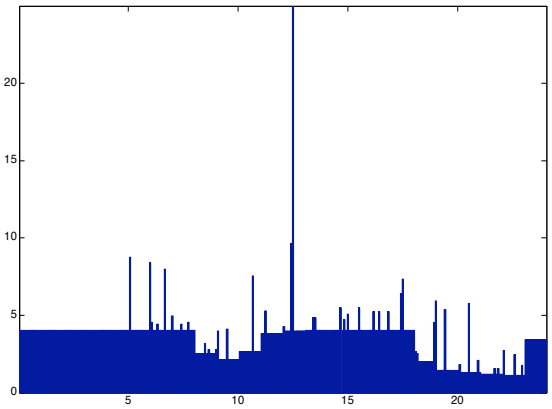
- Five Dwelling Types
  - Terraced, Semi-Detached, Detached, Bungalow, Flat
- Three Insulation Cases
  - Existing Stock, Hypothetical Refurbishment, Recently Constructed (2002 Building Regs)
- Space Heating Profile is technology dependent and user dependent
- Domestic Hot Water (DHW) model from IEA Annex 26 (300 litres, 200 litres, 100 litres per day)

For example, Terraced housing…

Terraced house

Insulation Case	*Annual Space Heating Demand*
Existing House	14,600 kWh
Refurbished House	10,600 kWh
Recently Constructed House	6,400 kWh





3 Micro-CHP Technologies

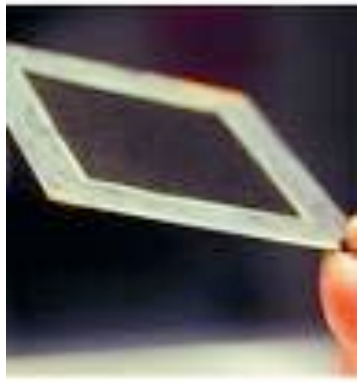
Stirling Engine

Source: Whispergen

Internal Combustion Engine

Source: Honda

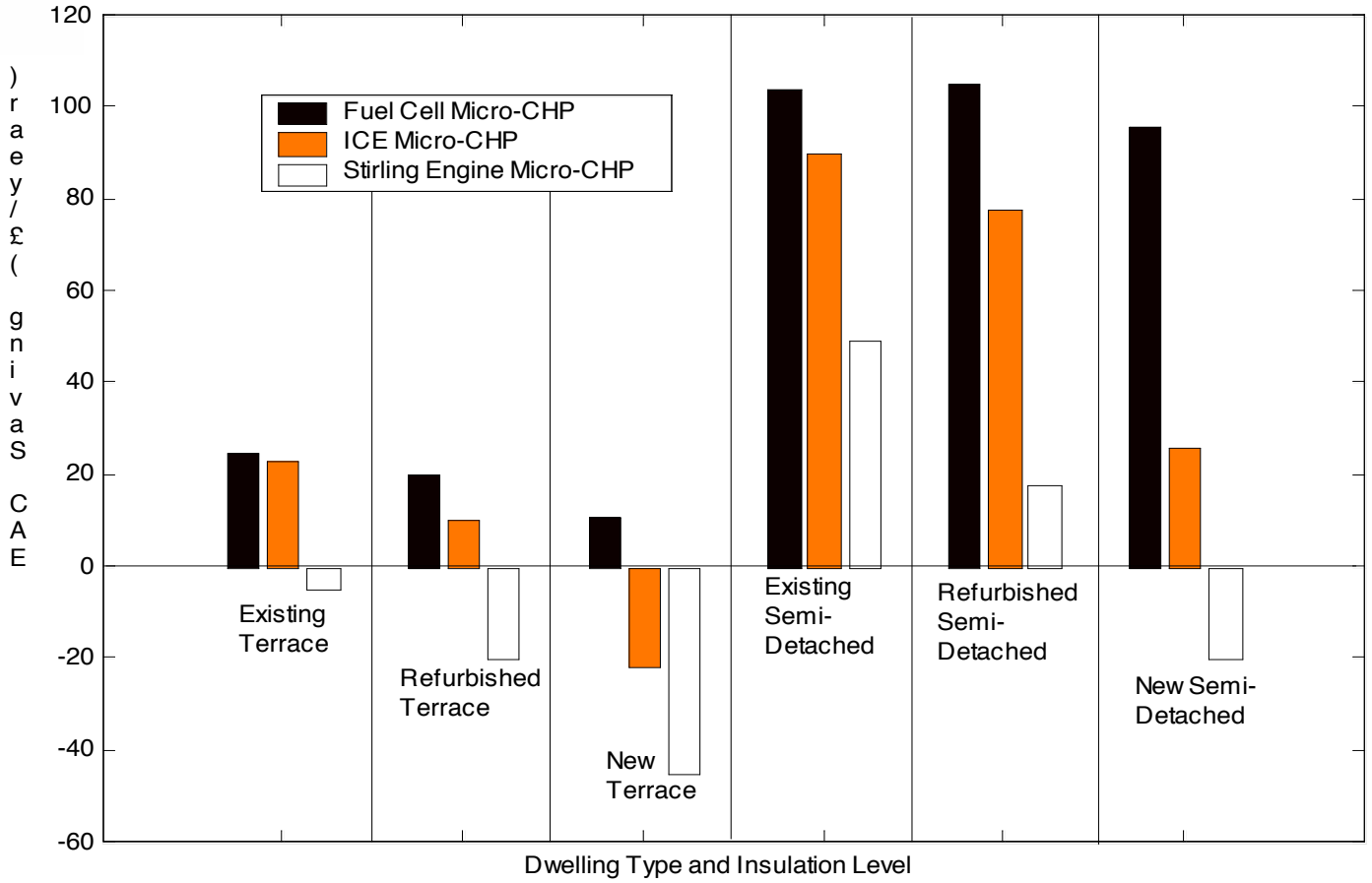
Generic Fuel Cell



Source: Ceres Power

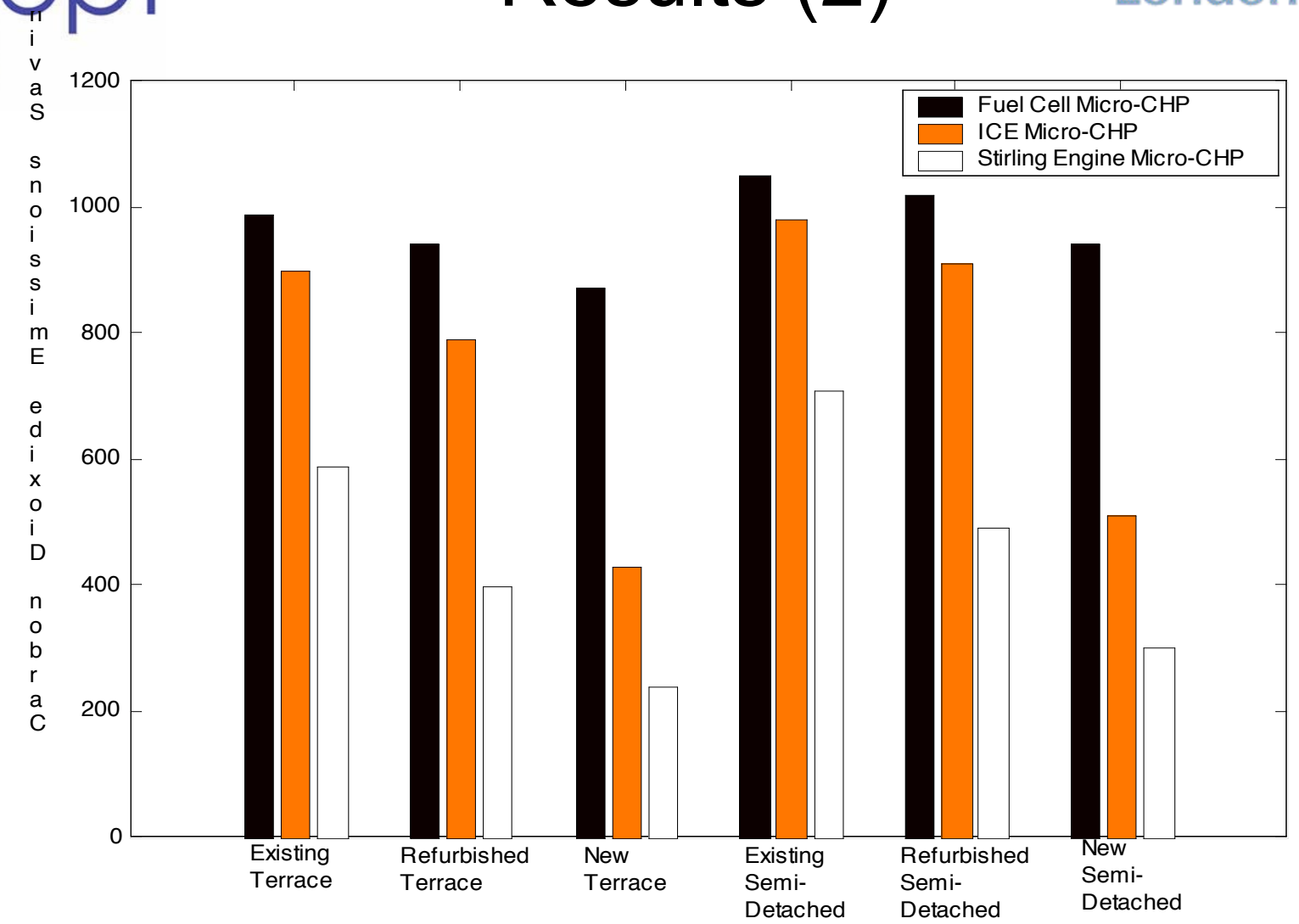
	Max Electrical Efficiency (LHV)	Overall Efficiency (LHV)	Minimum Output	Max Ramp Rate (per minute)
Condensing Boiler **(BASELINE CASE)**	-	90%	-	100%
1kWe Stirling Engine	15%	90%	0 kWe	25%
1kWe ICE	25%	90%	0 kWe	25%
1kWe Fuel Cell	40%	90%	0.2 kWe	5%

Results (1)



Equivalent Annual Cost (EAC) Savings versus Baseline (Grid/Boiler) for Three Micro-CHP Technologies for Terrace and Semi-Detached Dwellings

Results (2)



Carbon Dioxide Emissions Savings versus Baseline (Grid/Boiler) for Three Micro-CHP Technologies for Terrace and Semi-Detached Dwellings

Conclusion 1 – Economics & Environment

- Low heat to power ratio micro-CHP fares better as insulation improves
  - It can continue to operate when there is low heat demand.

- Market for micro-CHP
  - Market for low heat to power ratio micro-CHP is large
    - Fuel Cell Micro-CHP for >10,000kWh Annual Thermal Demand
    - ICE Micro-CHP for >13,000kWh Annual Thermal Demand
    - Stirling Engine Micro-CHP for > 17,000kWh Annual Thermal Demand
  - Flats are generally excluded from market.
  - Market for high heat to power ratio micro-CHP may be limited to poorly insulated or very large dwellings in the future.

Conclusion 2 – Emissions Reduction Policy Instruments

- Broad (or easily applicable) policy instruments may be difficult to formulate.
- Insulation and micro-CHP are not complimentary:
  - May be inadvisable to support high HPR micro-CHP in poorly insulated dwellings.
  - Could support low HPR technology in dwelling with medium to large demand, but;
- Ex-ante carbon savings could be roughly estimated based on annual thermal demand, annual electricity demand, and heat to power ratio of micro-CHP technology.
- Which order to install CERT measures?
  - Order effects emissions reduction attributable to each measure
  - Both efficiency and (some) micro-CHP are desirable
- Risk vs Reward
  - Efficiency is low risk, proven results
  - Micro-CHP is high risk, unproven results, but modelled potential is great (for some technologies).
- Zero carbon new homes by 2016? What place for micro-CHP?