



Micro-Generation : Opportunities & Barriers

Opportunities
& Barriers

'The Smiths'

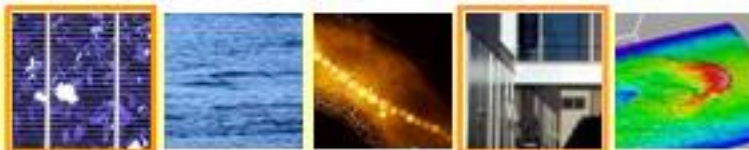
Micro-CHP

Micro-Wind

Micro-PV

Micro-
generation
Case Study

Policy
Changes



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Microgen ... decentralised power generation

Opportunities
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OPPORTUNITIES

**Ultimately a new type
of energy grid**

**Sustainability /
CO₂ savings**

**Raise End-User
Energy Awareness**

Part L trade-off

Planning Permission

Green Credentials

BARRIERS

Up front costs

Early Adopter Risk

**Electricity metering
arrangements**

**UK tax policy
(capital allowances)**



The 'Smiths' live in a 1930's semi ... They need more space ...

Opportunities
& Barriers

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The 'Smiths' live in a 1930's semi ...

They build a conservatory and then remove the thermal barrier to the house ...



**Space Heating:
20,000 kWh per annum**

**Electrical Demand:
4,000 kWh per annum**

**Opportunities
& Barriers**

'The Smiths'

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**Micro-
generation
Case Study**

**Policy
Changes**



The 'Smiths' live in a 1930's semi ...

Rising fuel bills, climate change ...
... What could the Smiths do?

Opportunities
& Barriers

'The Smiths'

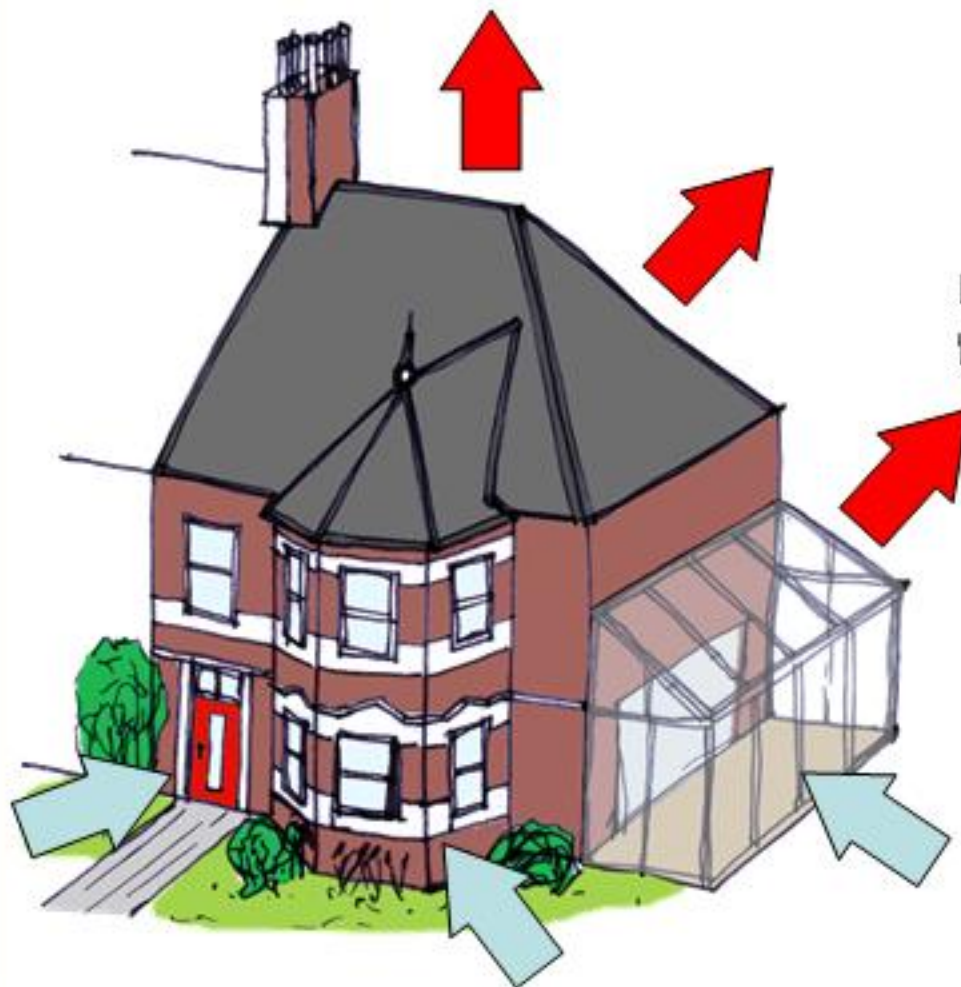
Micro-CHP

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Understand ...
What are the energy flows?



The 'Smiths' live in a 1930's semi ...

Building Refurbishment

Cavity wall and loft insulation, glazing replacement, boiler upgrade ...

Heating saving: 10,000 kWh per annum



Understand ...
What are the energy flows?

Opportunities
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'The Smiths'

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The 'Smiths' live in a 1930's semi ...

Rising fuel bills, climate change ...
... What else could the Smiths do?



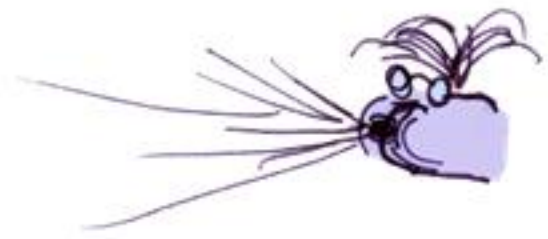
Understand ...
What are the energy flows?
What are the energy resources?



- Opportunities & Barriers
- 'The Smiths'
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The 'Smiths' live in a 1930's semi ... Ground Coupled Heat Pump?



**Understand ...
What are the energy flows?
What are the energy resources?**



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The 'Smiths' live in a 1930's semi ...

Photovoltaics? Solar thermal?

1,000 – 3,000 kWh per annum electrical

2,000 – 4,000 kWh per annum hot water



**Understand ...
What are the energy flows?
What are the energy
resources?**



Opportunities
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The 'Smiths' live in a 1930's semi ...

Micro-wind?

500 – 1,000 kWh per annum electrical



Understand ...
What are the energy flows?
What are the energy resources?



Opportunities
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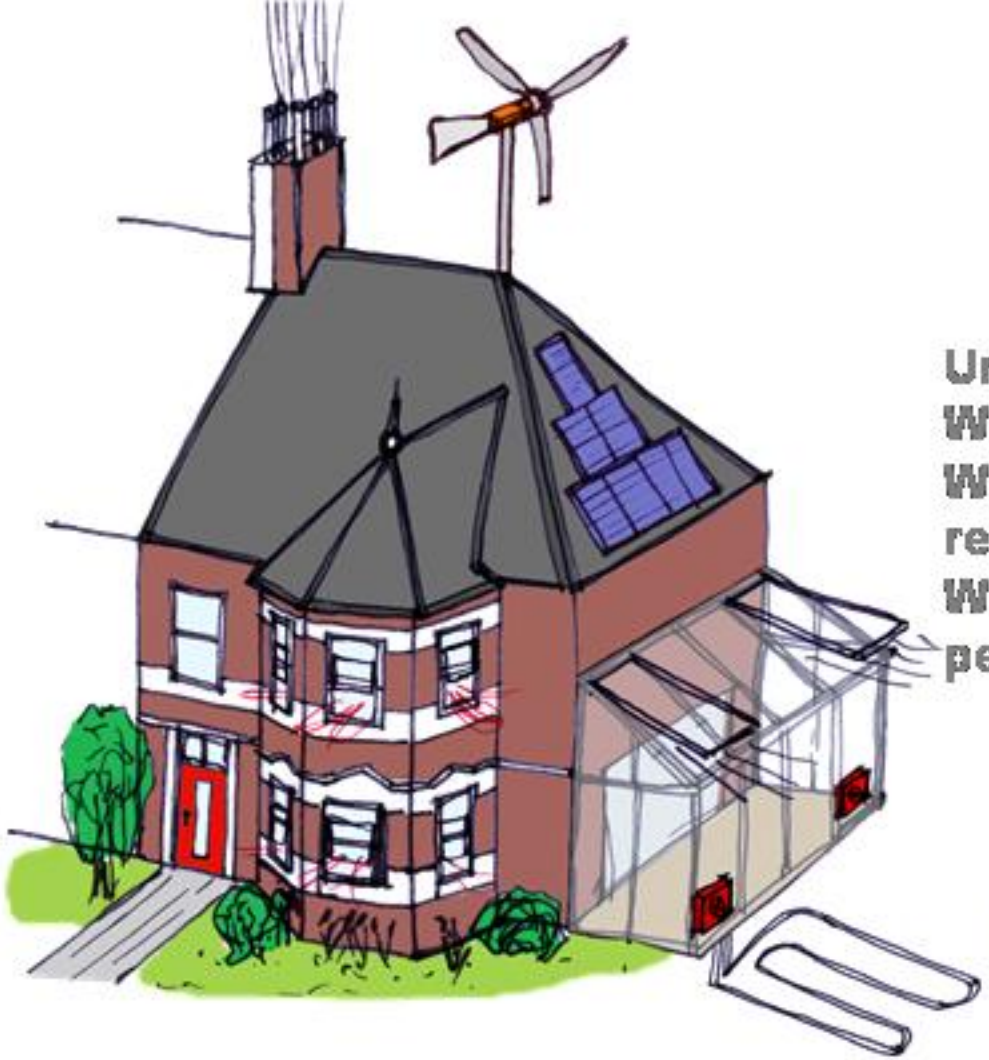
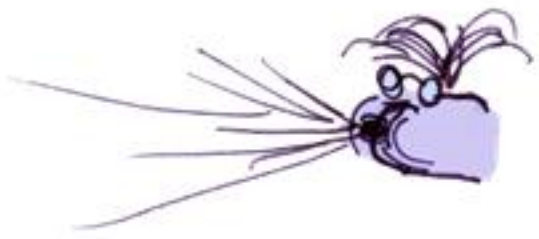
Policy
Changes



The 'Smiths' live in a 1930's semi ...

Personal behaviour?

10,000 kWh thermal, 1,000 kWh electrical



Understand ...
What are the energy flows?
What are the energy resources?
What is the impact of personal behaviour?



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So ... for a building we need to understand ...

Opportunities & Barriers

'The Smiths'

Micro-CHP

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Micro-generation Case Study

Policy Changes

**LOAD PROFILE
(User Behaviour)**

**Commercial –
Heating & Cooling
Domestic – Heating**

**ENERGY
RESOURCE**

**Wind Profile
Solar Irradiance
Ground**

TECHNOLOGY

**Photovoltaics
CHP
Micro-Wind**

**BUILDING
REFURBISHMENT**

**Commercial –
Summer Cooling
Domestic – Heating**



Micro-generation Technologies



**SOLAR DOMESTIC
HOT WATER SYSTEM**

Thermal Generation

**GROUND SOURCE
HEAT PUMP**

Thermal Generation

**BIOMASS BOILER
HW AND CENTRAL
HEATING**

Thermal Generation



**MICRO-CHP
Stirling engine
Fuel Cell**

Thermal & Electricity Generation –
Export issues

MICRO-WIND

Electricity Generation – Export issues

MICRO-PV

Electricity Generation – Export issues

Opportunities
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Combined Heat and Power Plant, University of Southampton

Opportunities
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2.8MW CHP unit –
Serves half of the main
campus (60% thermal)

Domestic Micro-CHP unit

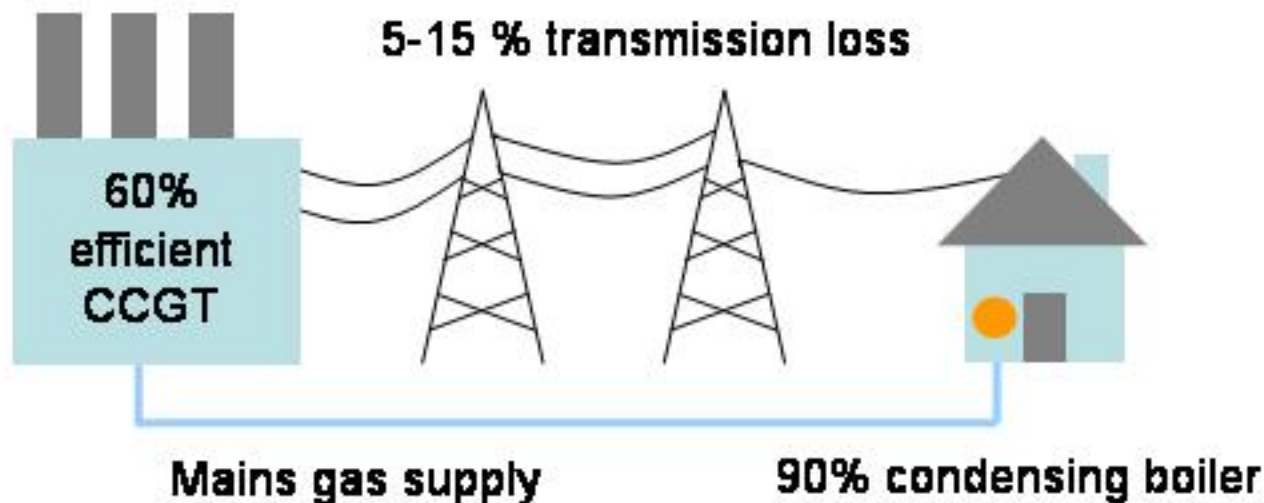


<http://www.whispergen.com>

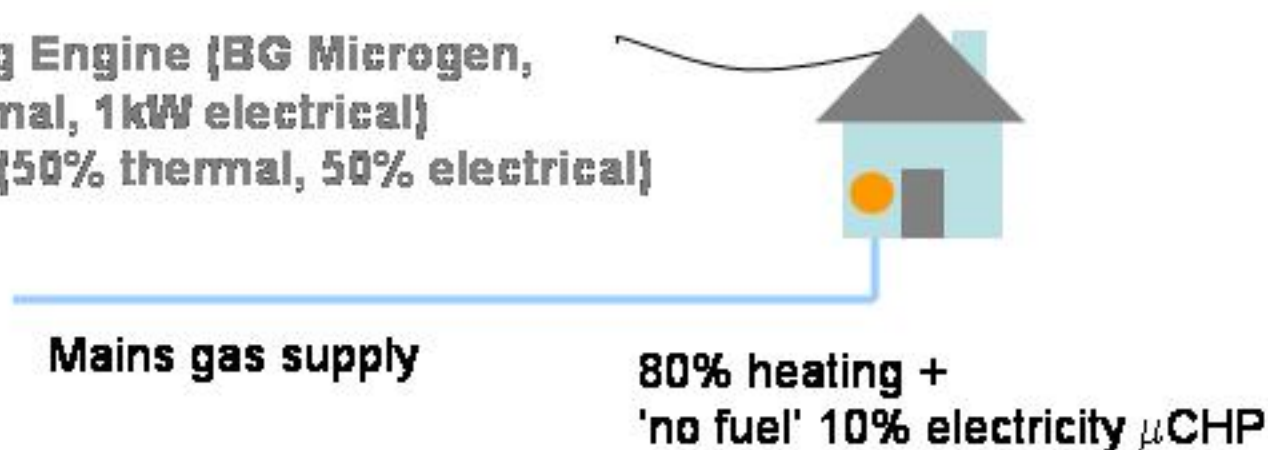


What is Micro-CHP?

{1} Conventional System



{2} Stirling Engine {BG Microgen, 6kW thermal, 1kW electrical}
Fuel Cell {50% thermal, 50% electrical}



Opportunities
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Potential Benefits of Micro-CHP?



**The
'Smiths'
house**

- Space Heating 19,521 kWh
- Hot water demand 3,833 kWh
- Electricity demand 2,618 kWh

Standard Boiler

Heating 90% efficiency
~~25,948 kWh gas~~

Electricity

~~Demand 2,618 kWh~~
Generate 0 kWh
Export 0 kWh

Micro-CHP (min. run time 2hrs)

(5-15 kW thermal - 1,100W electric)

Heating 80% efficiency
~~30,685 kWh gas (heat dump 1,114 kWh)~~

Electricity

~~Demand 2,618 kWh~~ **4,645 kWh gas supply**
Generate 5,033 kWh
Export 3,527 kWh
Run time 4,576 hours **3,527 kWh electricity**

Micro-CHP **3,527 kWh** electricity = **6,531 kWh** gas fuel in CCGT
 Micro-CHP **gas saving = 1887 kWh** gas primary fuel (7% REDUCED)
 Micro-CHP **CO₂ saving = 509 kg** per annum (CCGT gas 0.27 kg CO₂/kWh)





Wind Power Micro-generation

Opportunities
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Micro-CHP

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High Rise Building,
Munich

**POWER \propto
wind speed³**



**RESOURCE
ASSESSMENT
IS CRITICAL**

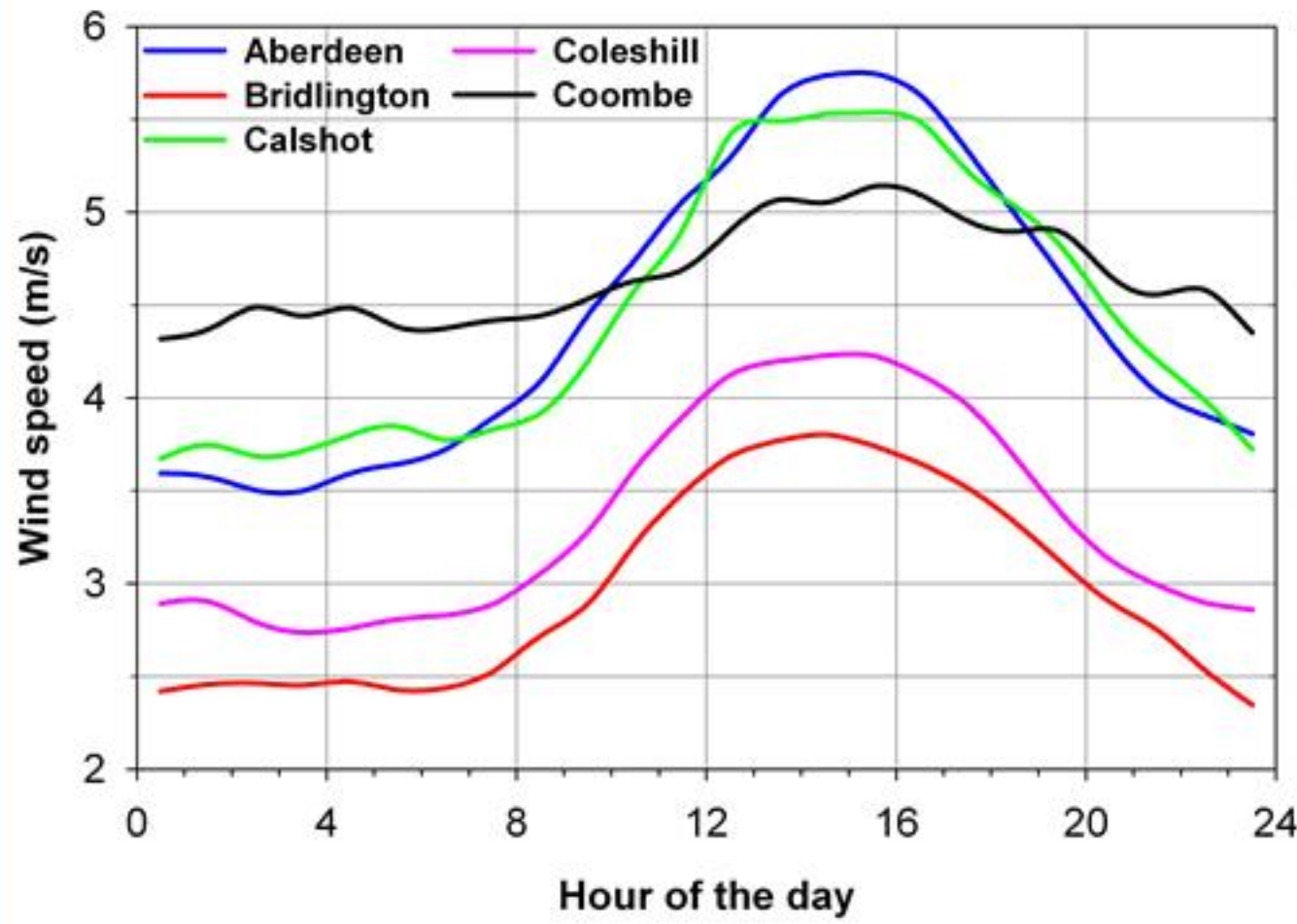
Domestic
House





Wind Power Micro-generation

✓ Daily wind profile is a good match for domestic use.



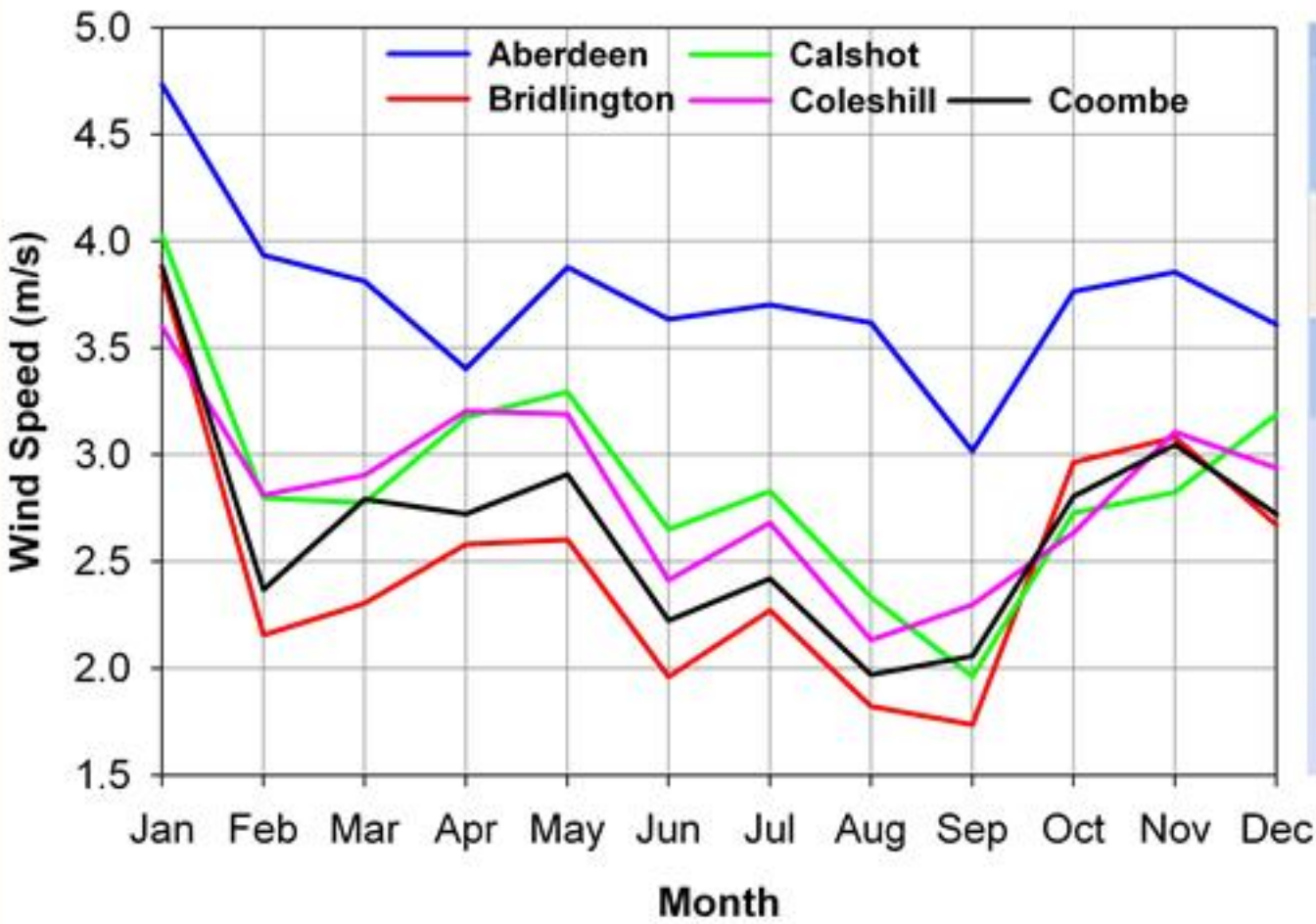
Location of sites in the UK

- Opportunities & Barriers
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Wind Power Micro-generation

✓ Annual wind profile is a good match for domestic use.



Location of sites in the UK

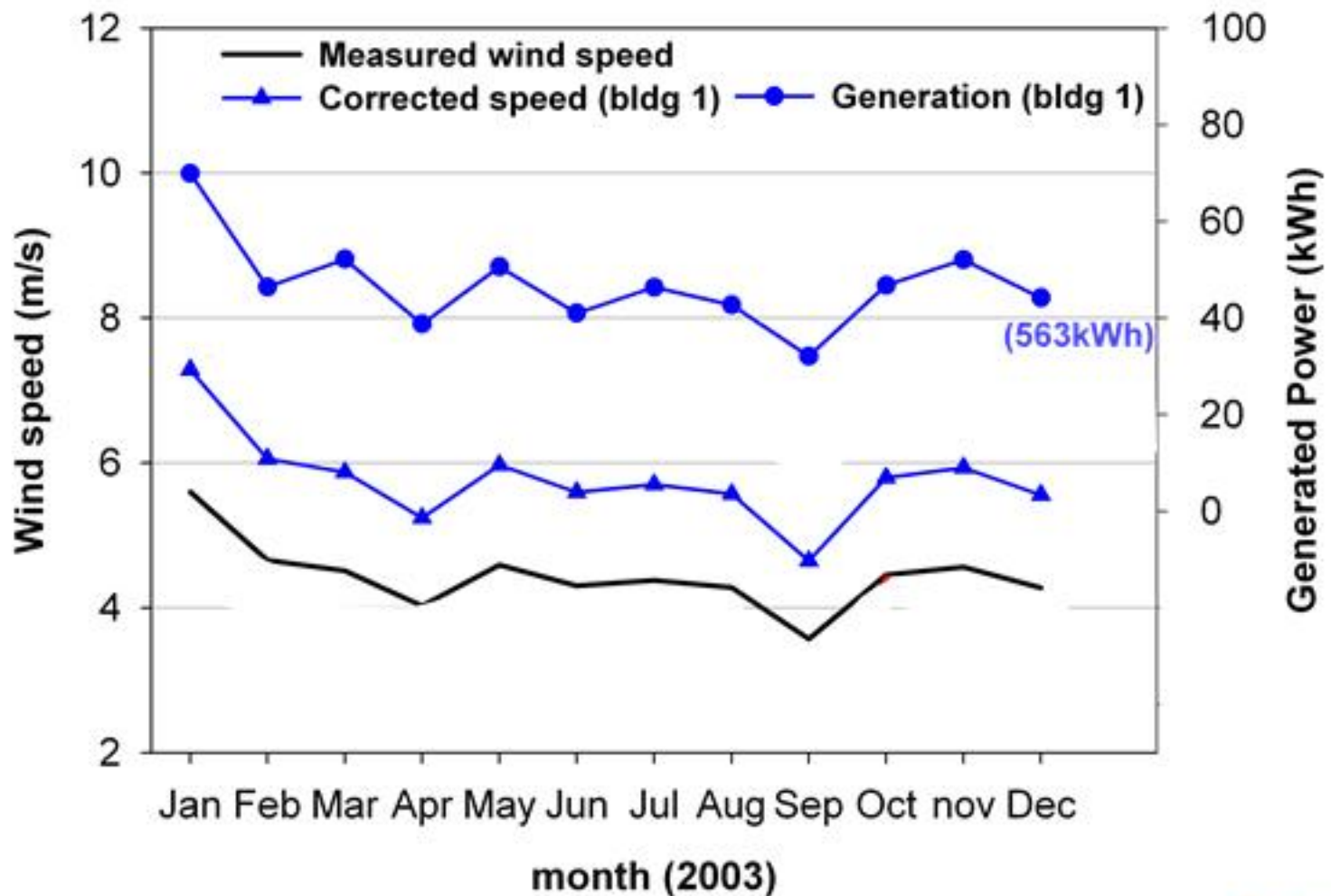
- Opportunities & Barriers
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Wind Power Micro-generation

Building 1 roof level is at 20m in suburban terrain

Building 2 is 10m in suburban terrain with 50% wind speed reduction within an arc of 180° - 240° representing a shadowing effect structure.



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

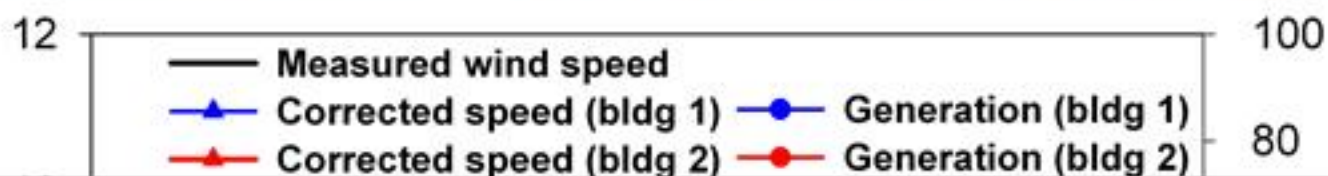
Policy Changes



Wind Power Micro-generation

Building 1 roof level is at 20m in suburban terrain

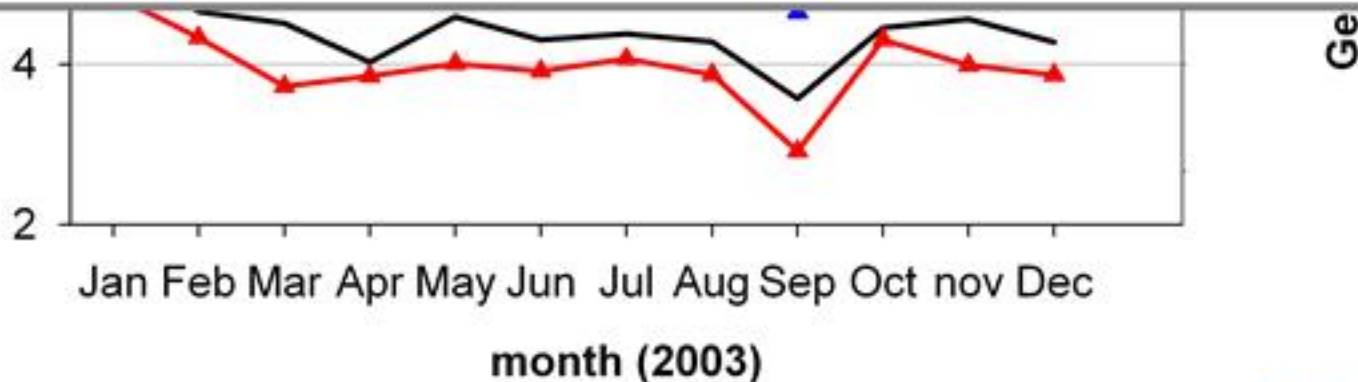
Building 2 is 10m in suburban terrain with 50% wind speed reduction within an arc of 180° - 240° representing a shadowing effect structure.



! BEWARE !

Wind shear and shadow effects dramatically reduce the potential wind resource.

Urban wind is problematic!



Opportunities & Barriers

'The Smiths'

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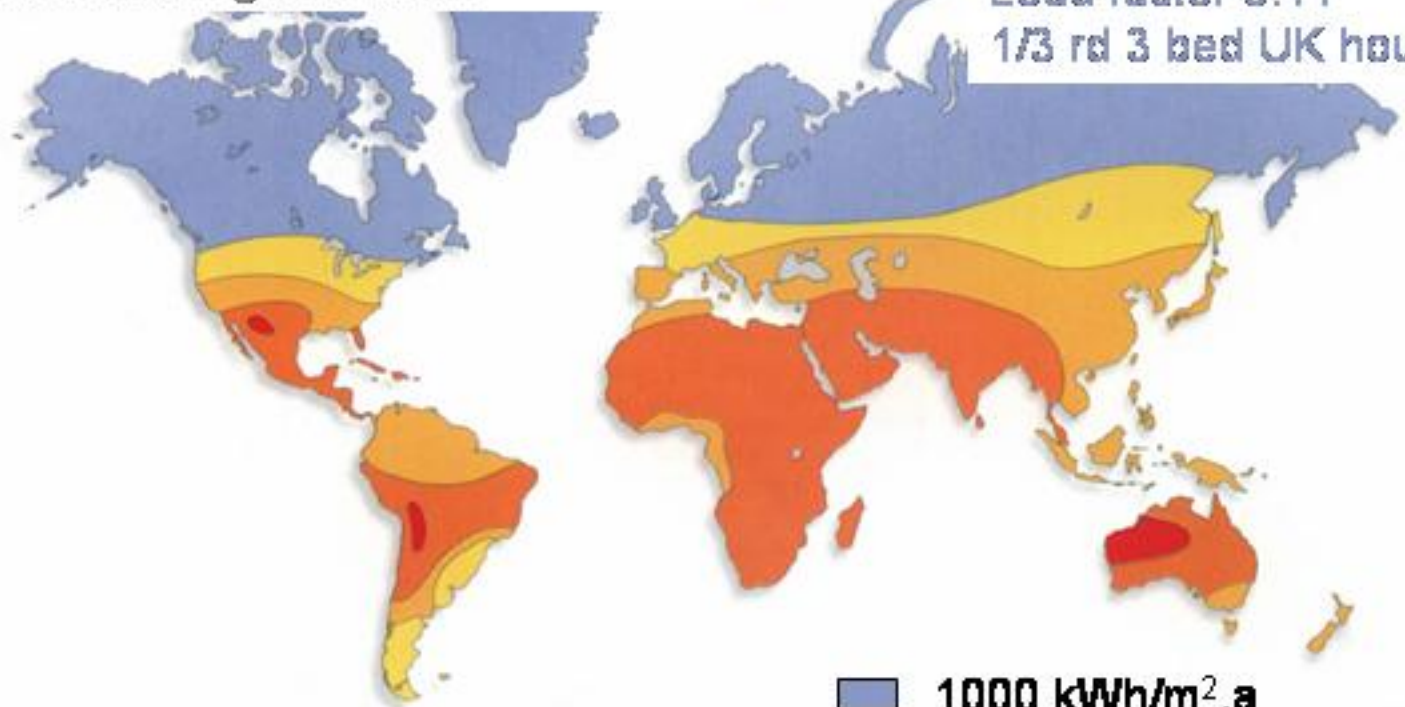
Policy Changes



Photovoltaics: Horizontal Irradiance Distribution

1kW PV in each region (£4K, 9m²).
How much generation?

1000 kWh / annum
Load factor 0.11
1/3 rd 3 bed UK house



2500 kWh / annum
Load factor 0.29
3 bed UK house

- 1000 kWh/m².a
- 1000 .. 1500 kWh/m².a
- 1500 .. 2000 kWh/m².a
- 2000 .. 2500 kWh/m².a
- >2500 kWh/m².a

- Opportunities & Barriers
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Building Integrated Photovoltaics - BiPV

- ✓ Electricity generation at point of use
- ✓ Obtain full value for electricity (avoided import tariff and no export)
- ✓ Multi-function elements - offset cost of PV
- ✓ Building added value - technology / environmental statement
- ✓ 30 year + lifetime for certain cell technologies
- × High capital cost, low power density



Opportunities
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Policy
Changes



**Opportunities
& Barriers**

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

**Micro-
generation
Case Study**

**Policy
Changes**



BiPV - Polycrystalline silicon curtain wall



Opportunities
& Barriers

'The Smiths'

Micro-CHP

Micro-Wind

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Micro-
generation
Case Study

Policy
Changes



BiPV - Polycrystalline silicon curtain wall



Opportunities
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Micro-CHP

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Policy
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BiPV – Etched Thin Film curtain wall



Opportunities
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BiPV – Thin Film curtain wall, unsound design



Opportunities
& Barriers

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Policy
Changes

BiPV – Mono, Poly-crystalline curtain wall (1MW Mont Cenis, D)



Opportunities
& Barriers

'The Smiths'

Micro-CHP

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Micro-PV

Micro-
generation
Case Study

Policy
Changes



BiPV – Mono, Poly-crystalline curtain wall (1MW Mont Cenis, D)



1997 Photovoltaic Facade, University of Southampton

Opportunities
& Barriers

'The Smiths'

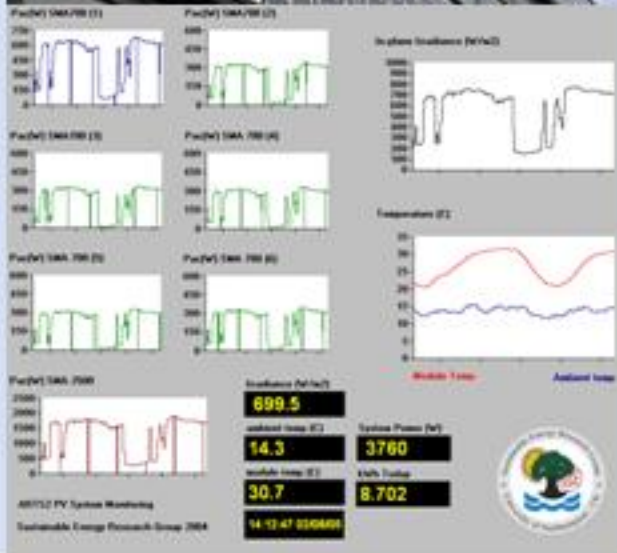
Micro-CHP

Micro-Wind

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Policy
Changes



BiPV – 7.2 kWp Mono-crystalline façade



2005 PV Atrium, University of Southampton

Opportunities
& Barriers

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Policy
Changes



12.2 kWp

Mono-crystalline glazing

Multi-function elements

- **Solar control shading**

- **Daylighting**

- **Weatherproof barrier**



Photovoltaic Roof Tile, University of Southampton

Opportunities
& Barriers

'The Smiths'

Micro-CHP

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Policy
Changes

- ✓ Design enables easy installation, repair and exchange
- ✗ Very little avoided cost, economic payback time 70 years +





PV Micro-generation Case Study

De-centralised PV generation
PV generation for domestic buildings –
generation out of phase with demand.



Opportunities
& Barriers

'The Smiths'

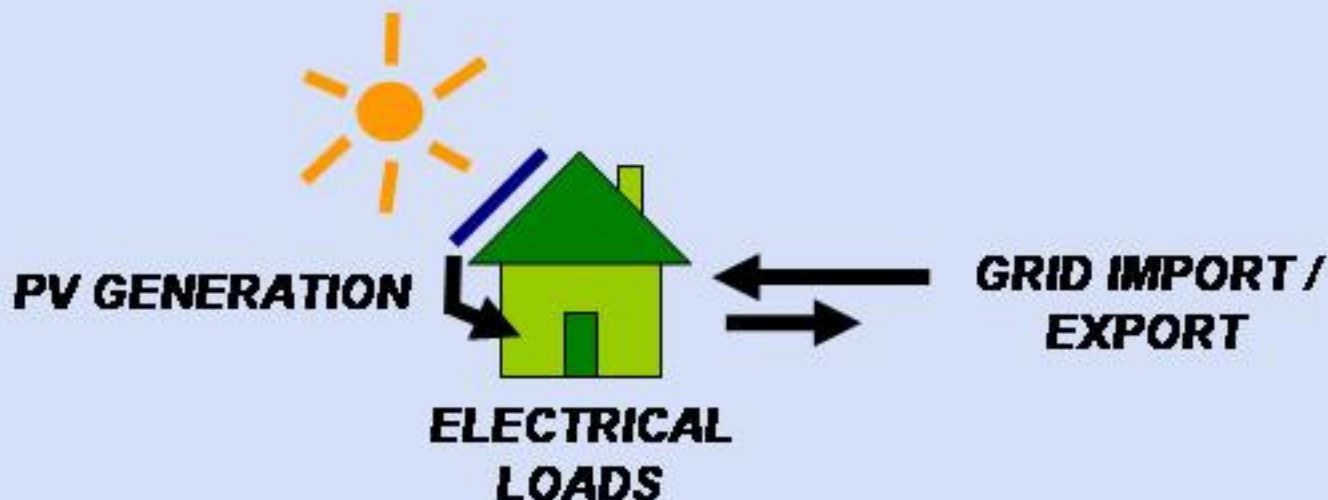
Micro-CHP

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Micro-
generation
Case Study

Policy
Changes





Optimisation of Load Matching for Micro-generation Electricity

Value to householder of generated electricity = Credit for number of units of electricity generated + Avoided electricity import through on-site use of generated electricity

Opportunities & Barriers

'The Smiths'

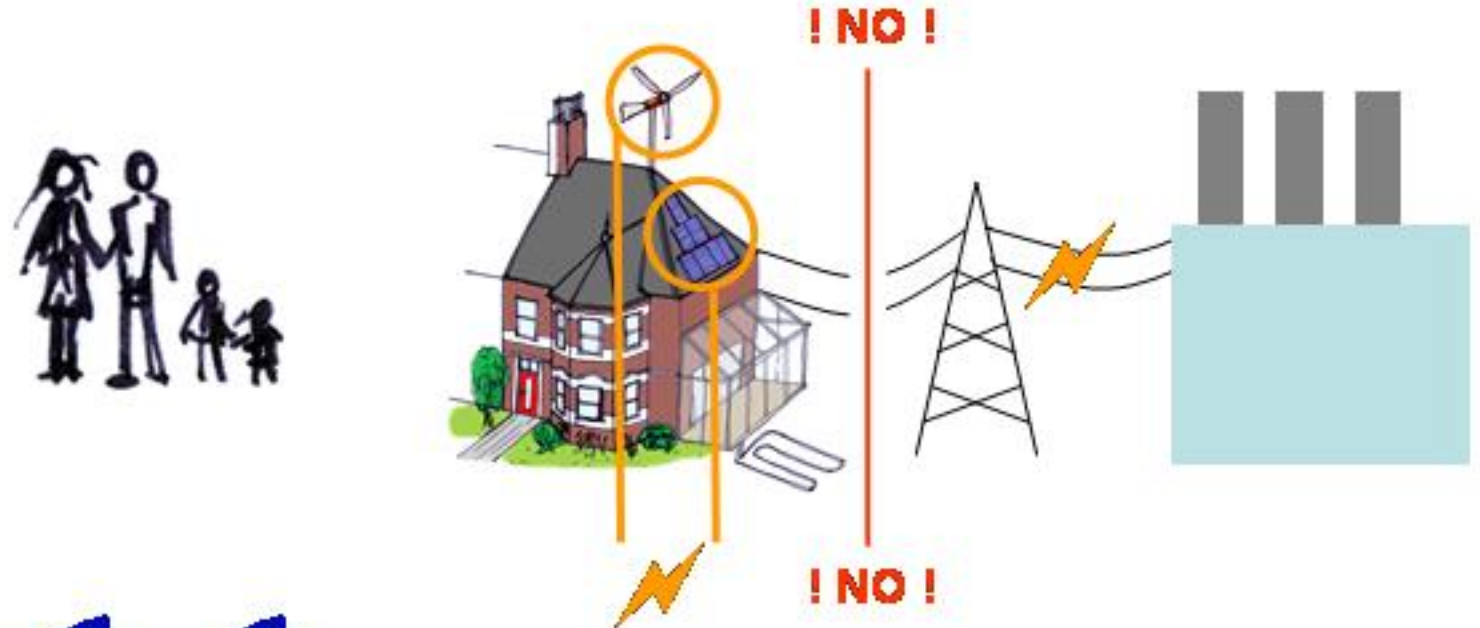
Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes



= **A = 4p/kWh**

+ **B = 10p/kWh**

Easy to predict for PV, more difficult for wind system

Dependant on householder behaviour



Eco-Home, Development, Hampshire, UK

Opportunities & Barriers

'The Smiths'

Micro-CHP

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Micro-generation Case Study

Policy Changes

Eco-home PV systems.

9 identical PV systems, 1530 Wp

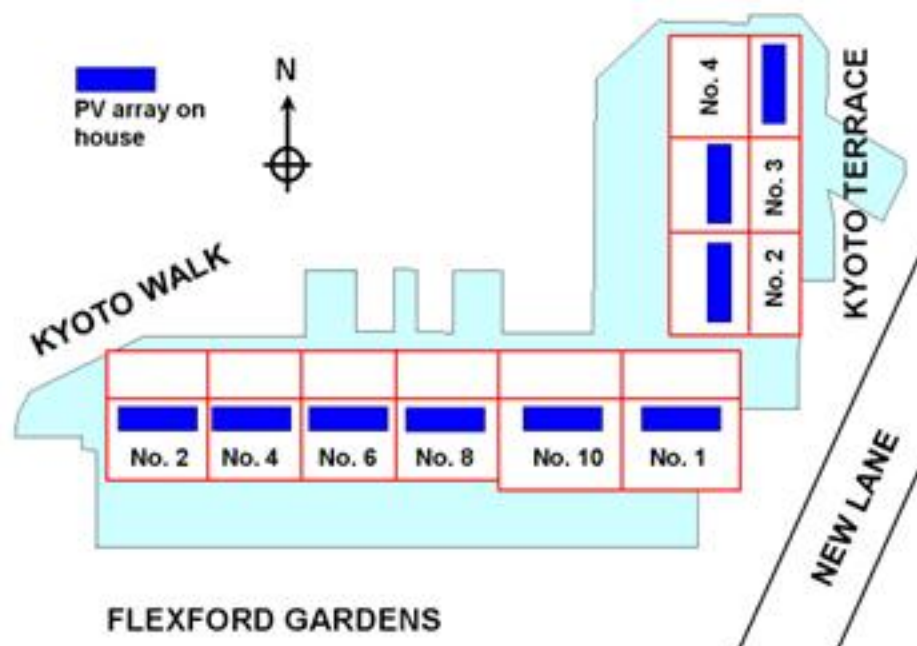
18 x BP585 laminates per house

2 x SMA700 string inverters

6 South facing, 2 West facing

1 East facing

Full data monitoring, environmental parameters, import, export and generation of electricity for each house.



Eco-Home, Development, Hampshire, UK

Opportunities
& Barriers

'The Smiths'

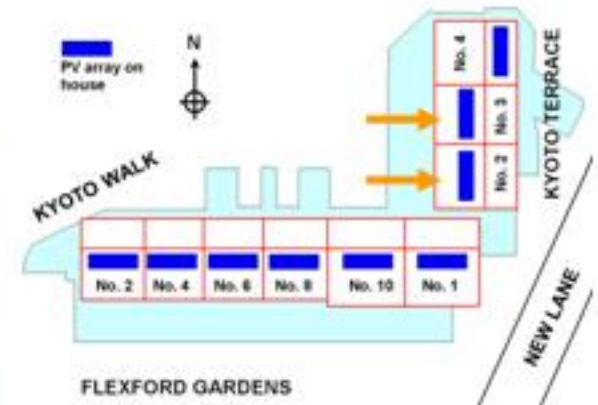
Micro-CHP

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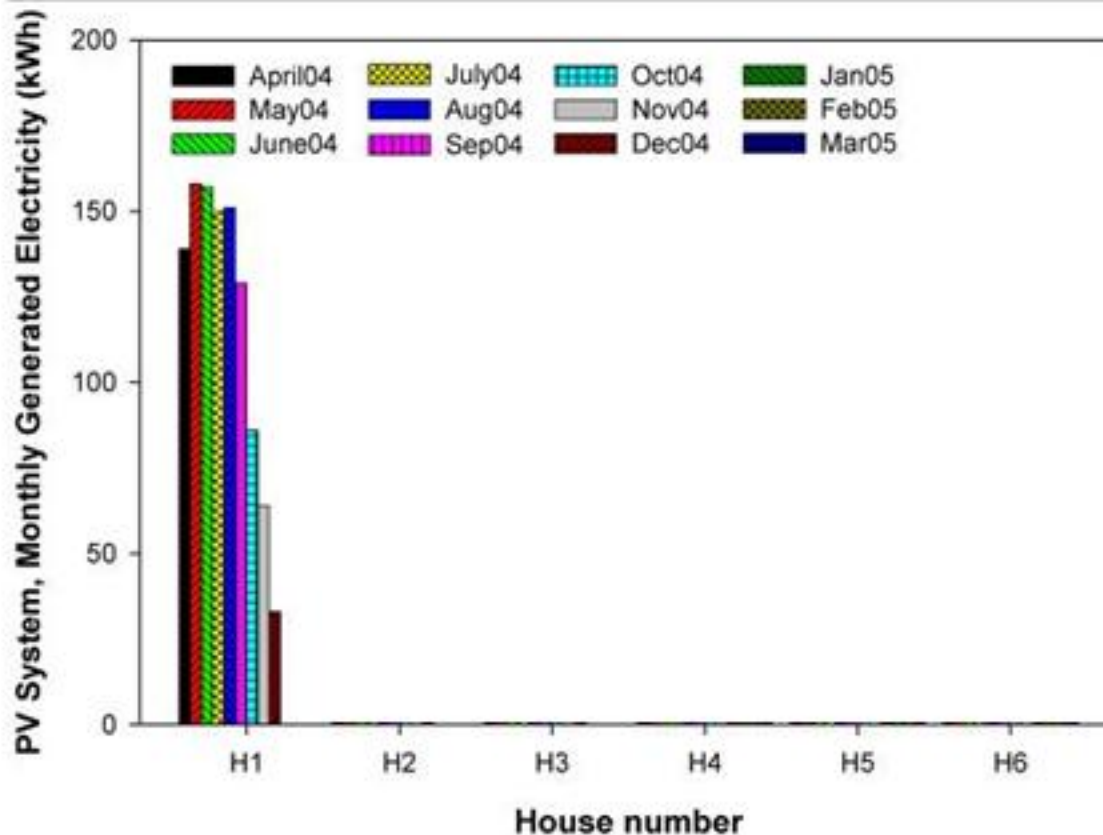
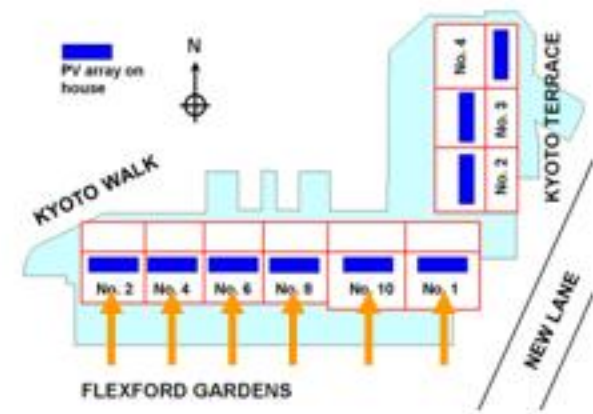
Micro-
generation
Case Study

Policy
Changes



New Lane, Havant

Generation from 1.53 kWp systems, H1..H6
April 2004..Mar 2005



Opportunities
& Barriers

'The Smiths'

Micro-CHP

Micro-Wind

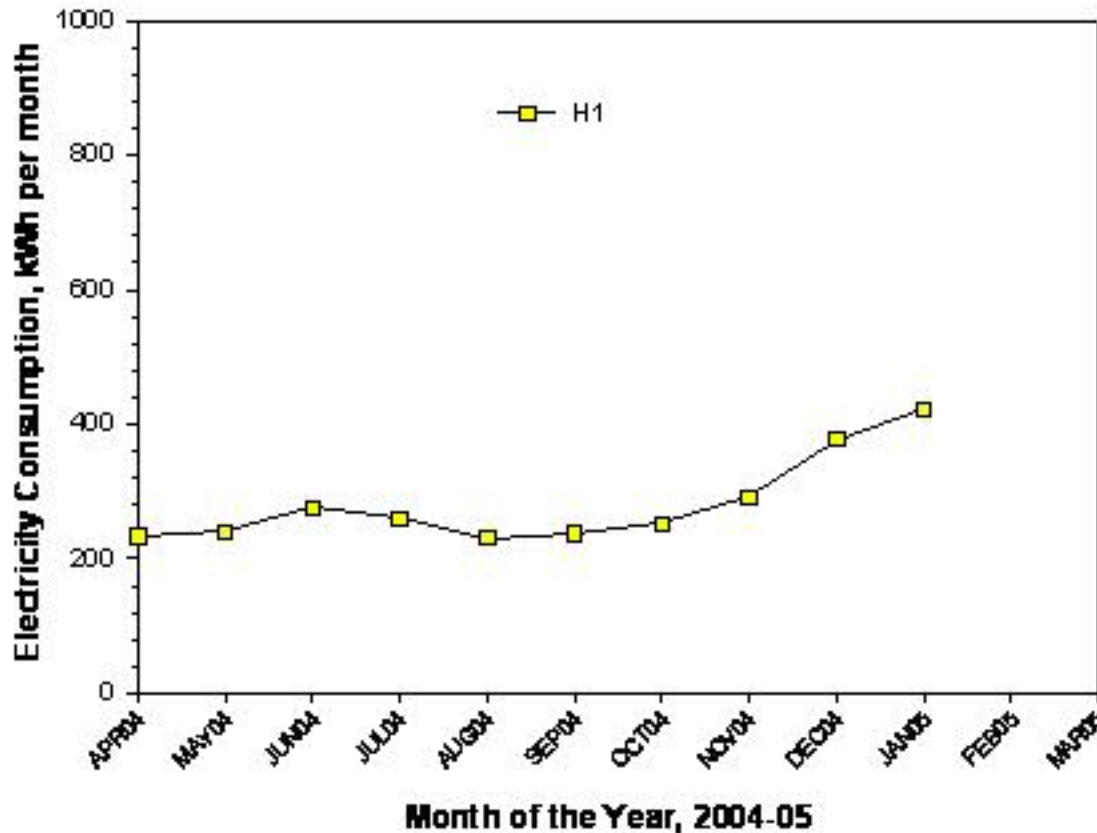
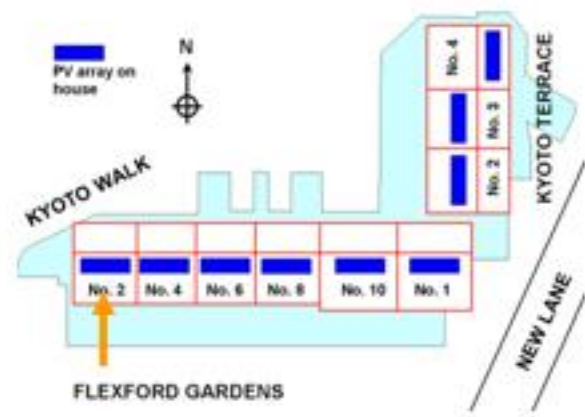
Micro-PV

Micro-
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Case Study

Policy
Changes

New Lane, Havant

Monthly Electricity Consumption, H1 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

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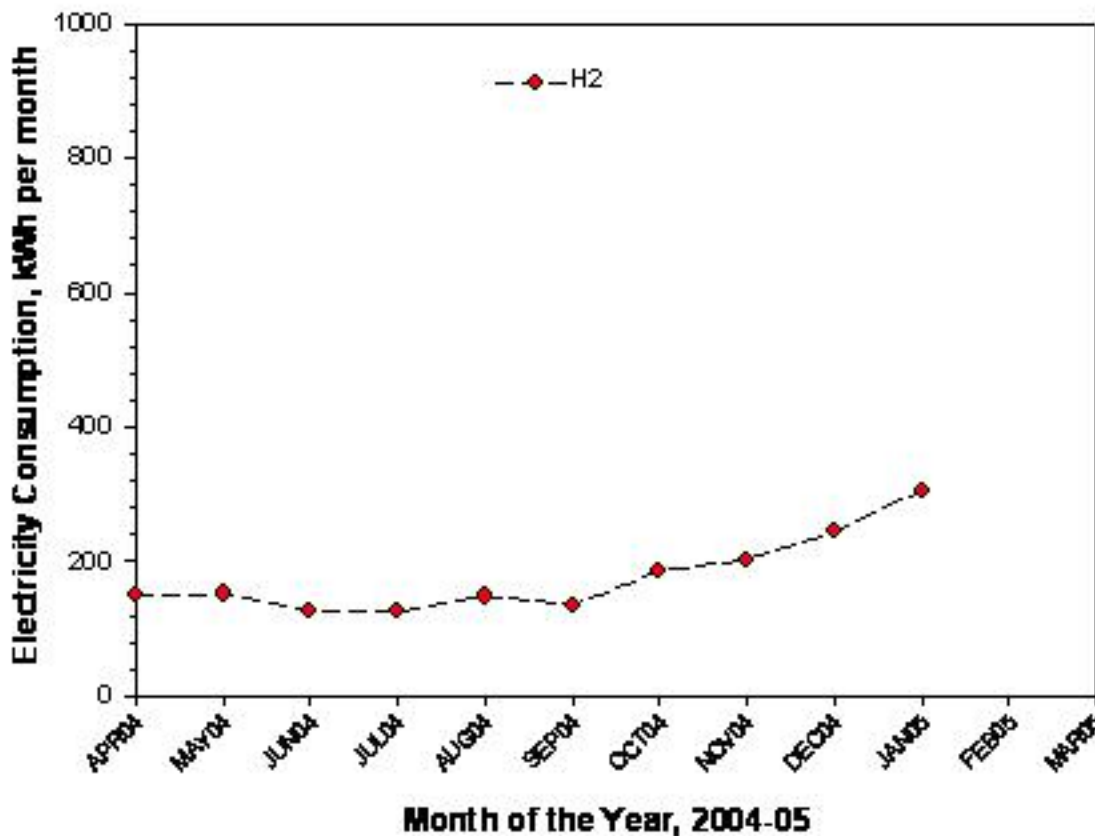
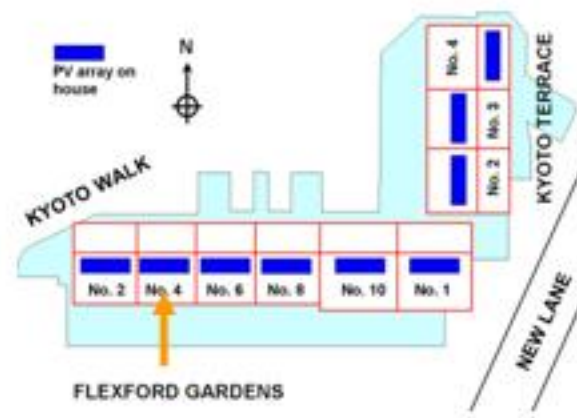
Micro-generation Case Study

Policy Changes



New Lane, Havant

Monthly Electricity Consumption, H2 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

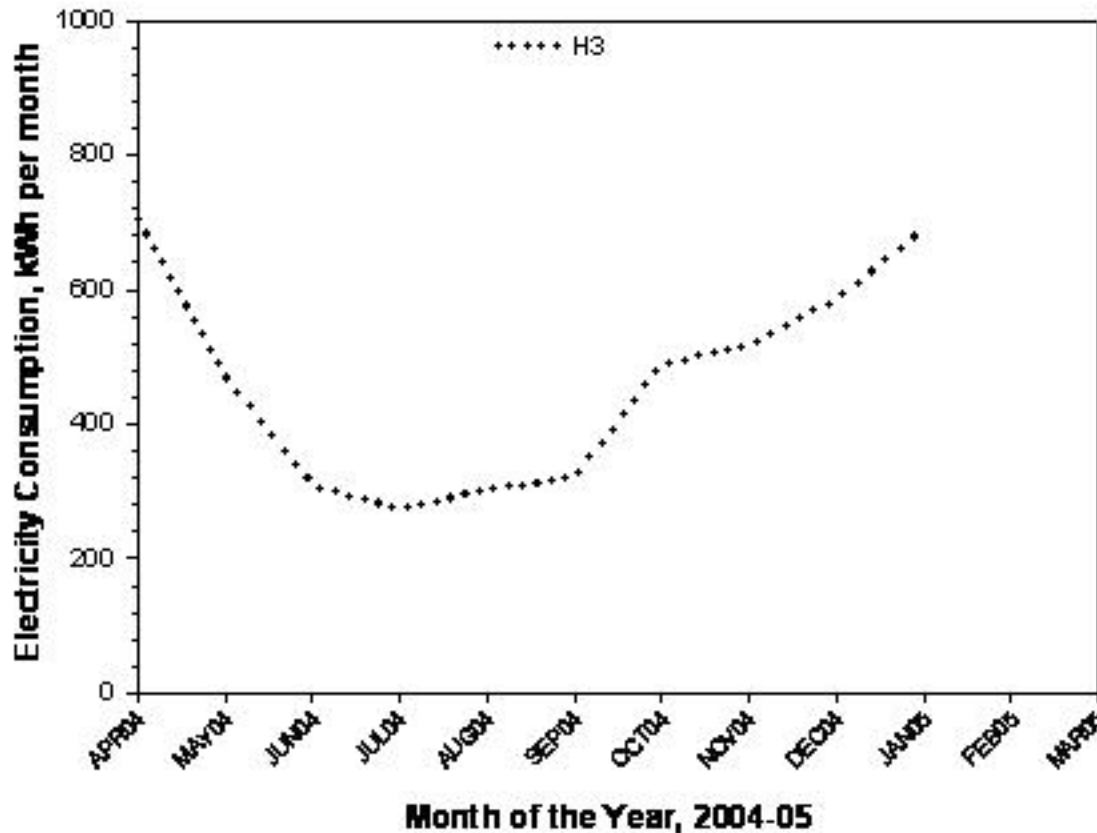
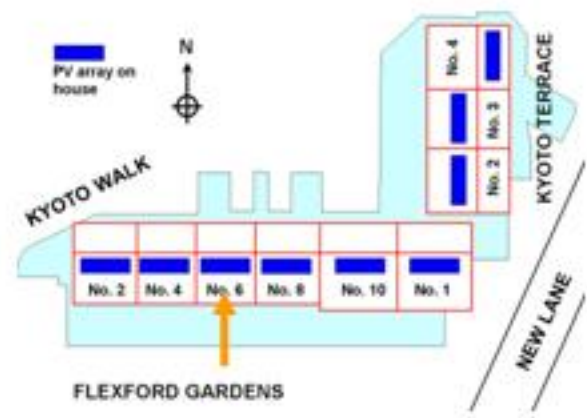
Micro-PV

Micro-generation Case Study

Policy Changes

New Lane, Havant

Monthly Electricity Consumption, H3 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

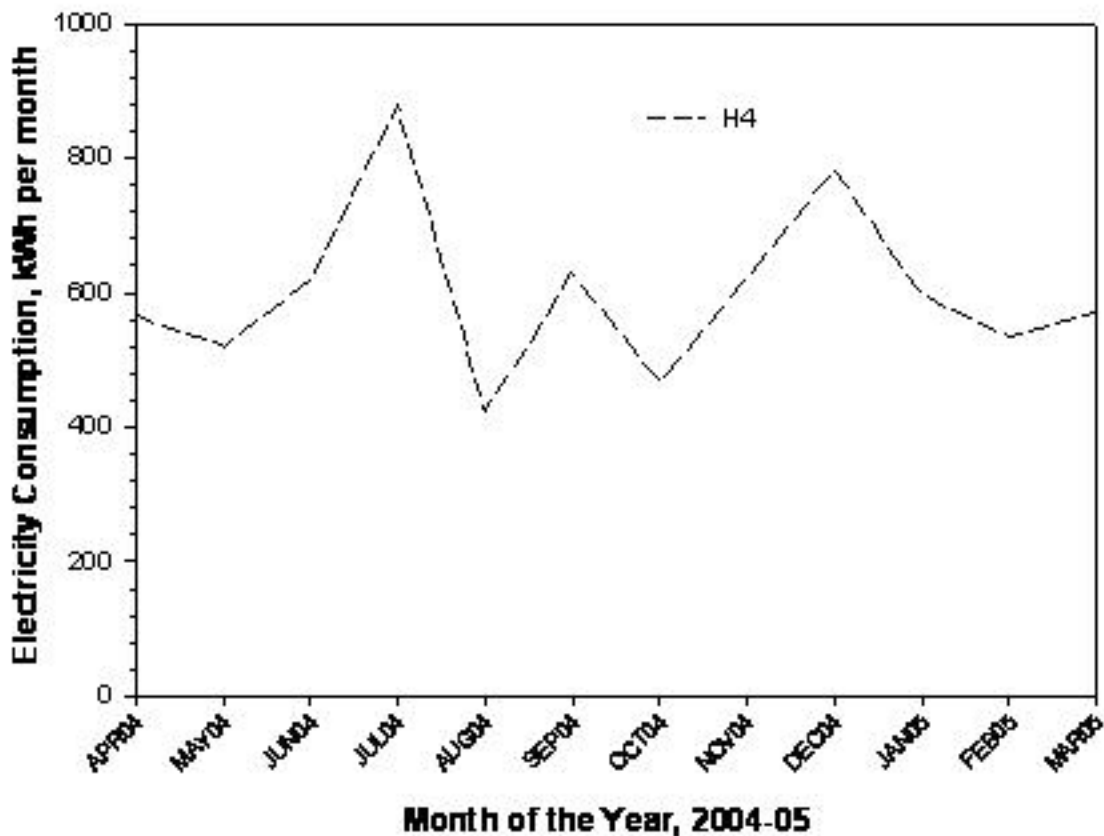
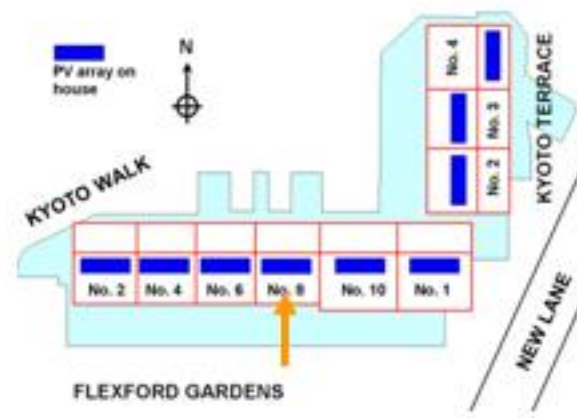
Micro-PV

Micro-generation Case Study

Policy Changes

New Lane, Havant

Monthly Electricity Consumption, H4 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

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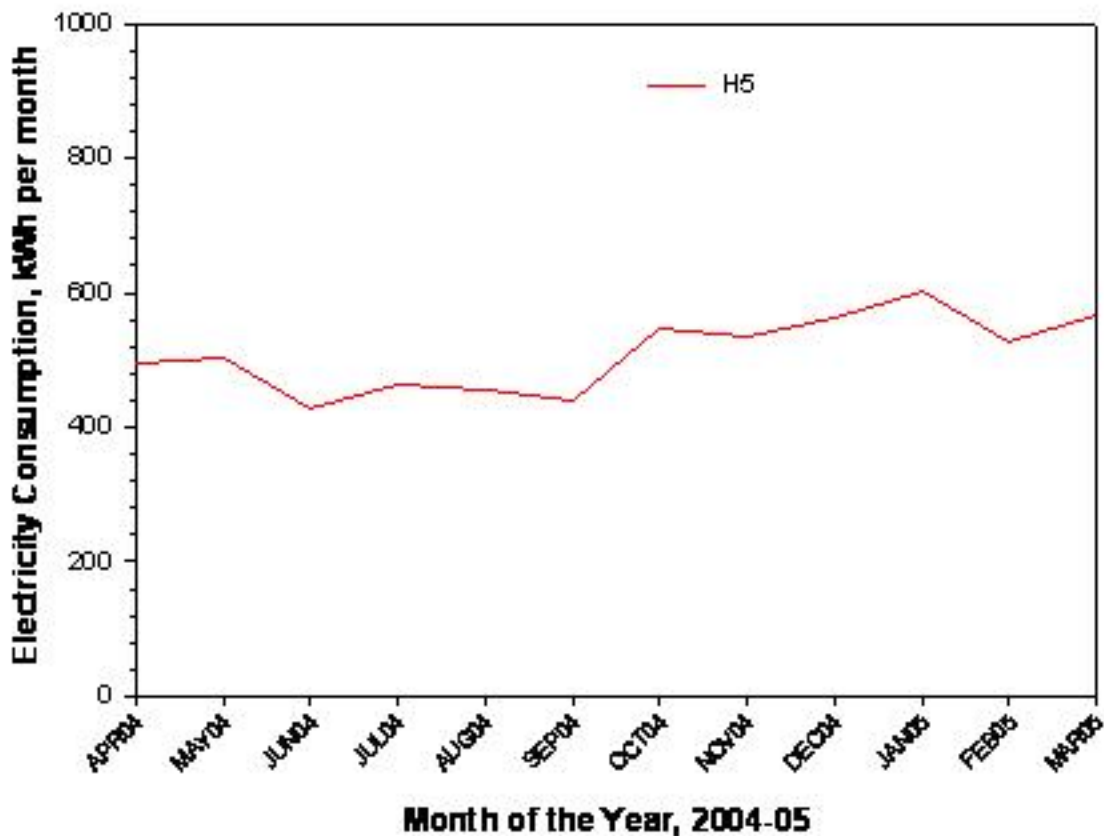
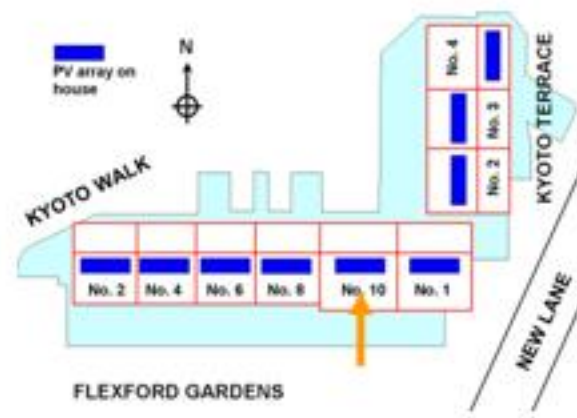
Micro-generation Case Study

Policy Changes



New Lane, Havant

Monthly Electricity Consumption, H5 April 2004..Mar 2005



Opportunities & Barriers

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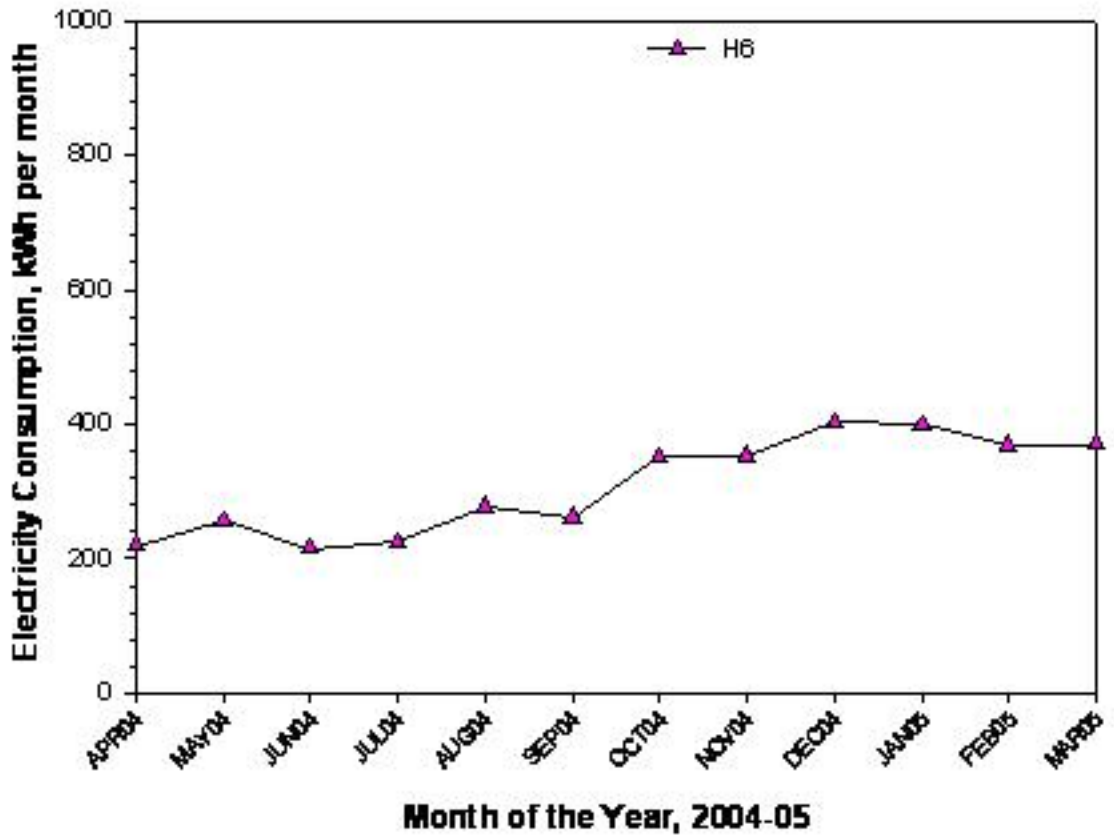
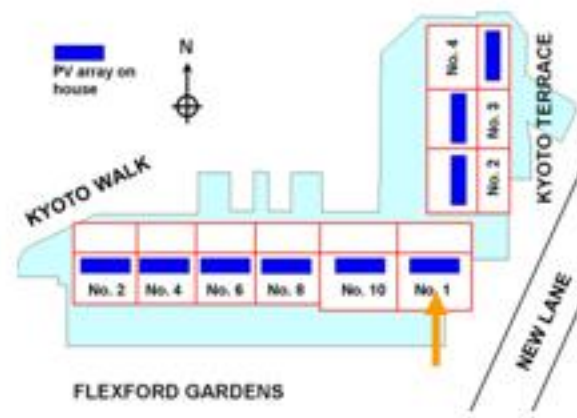
Micro-generation Case Study

Policy Changes



New Lane, Havant

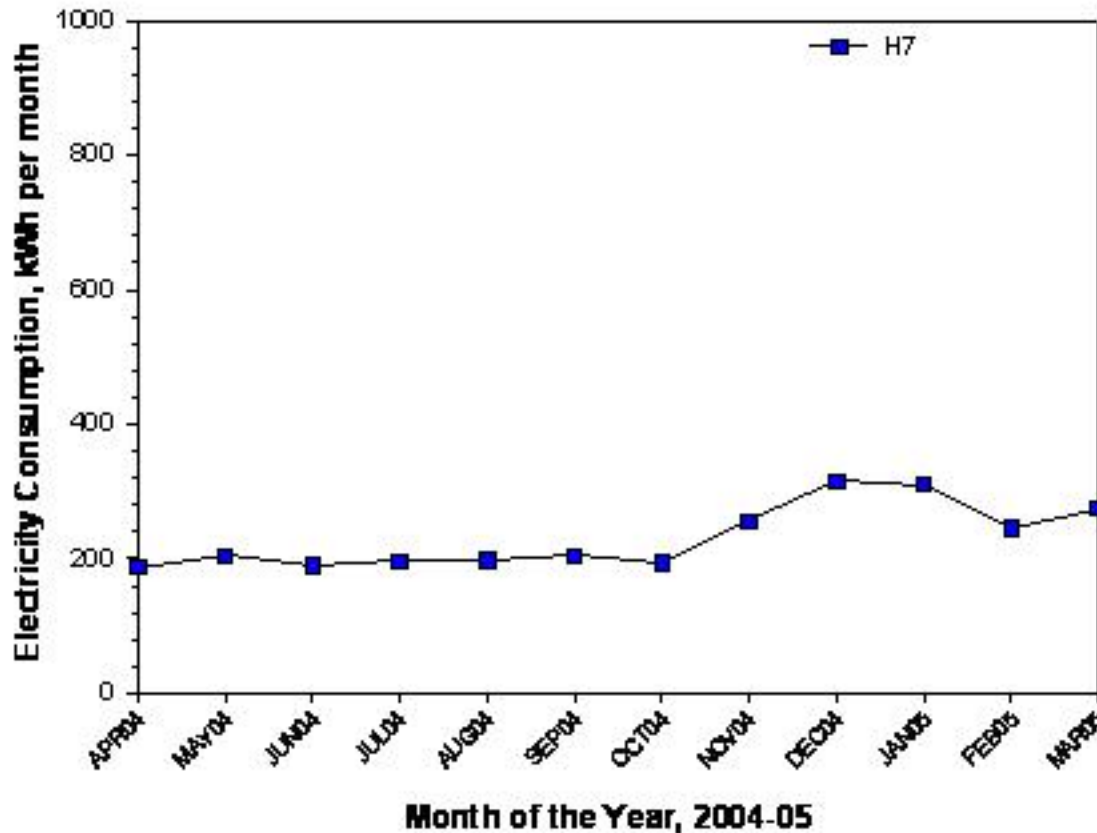
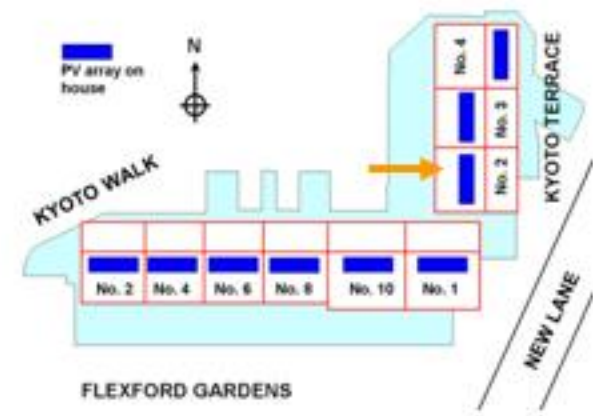
Monthly Electricity Consumption, H6 April 2004..Mar 2005



- Opportunities & Barriers
- 'The Smiths'
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New Lane, Havant

Monthly Electricity Consumption, H7 April 2004..Mar 2005



Opportunities & Barriers

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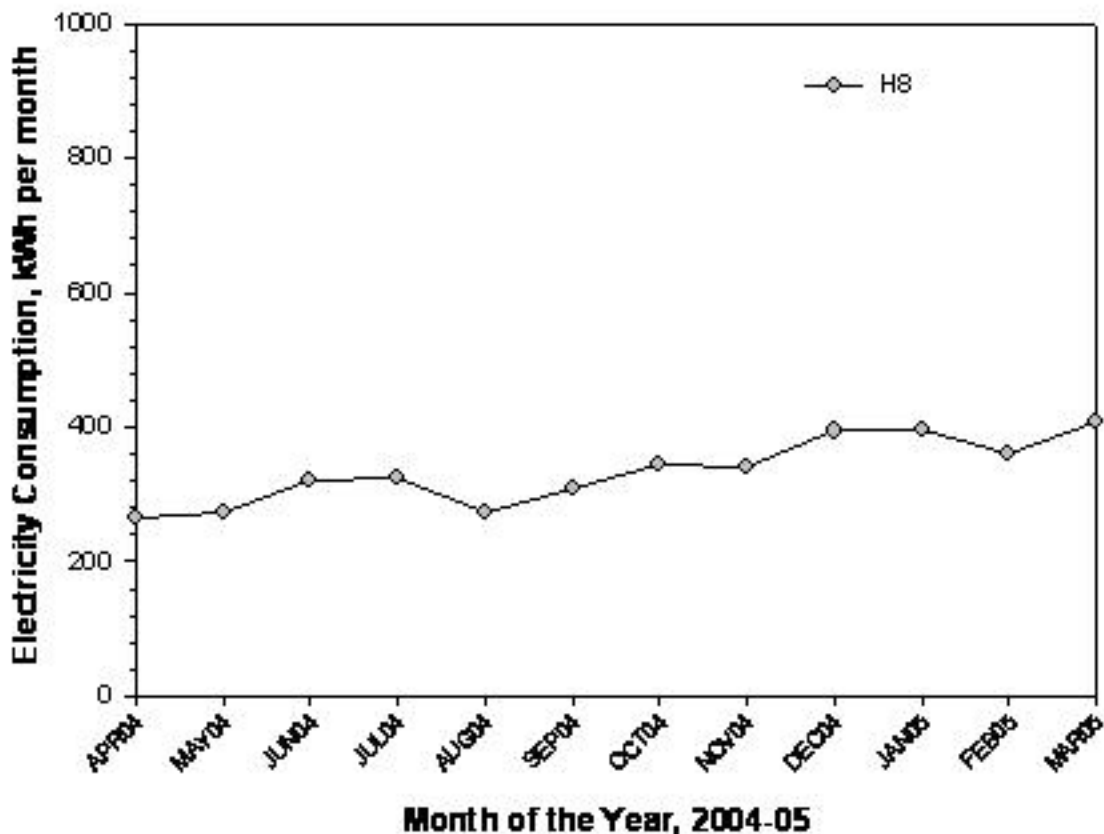
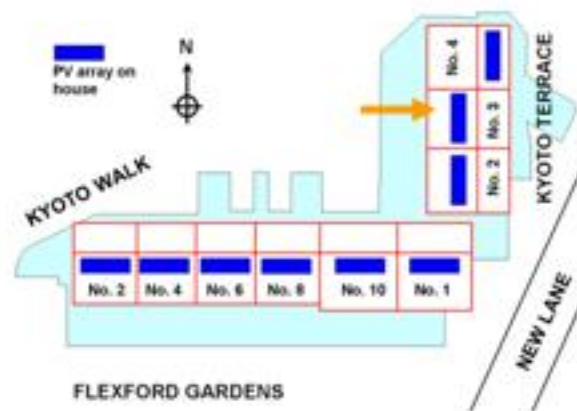
Micro-generation Case Study

Policy Changes



New Lane, Havant

Monthly Electricity Consumption, H8 April 2004..Mar 2005



Opportunities & Barriers

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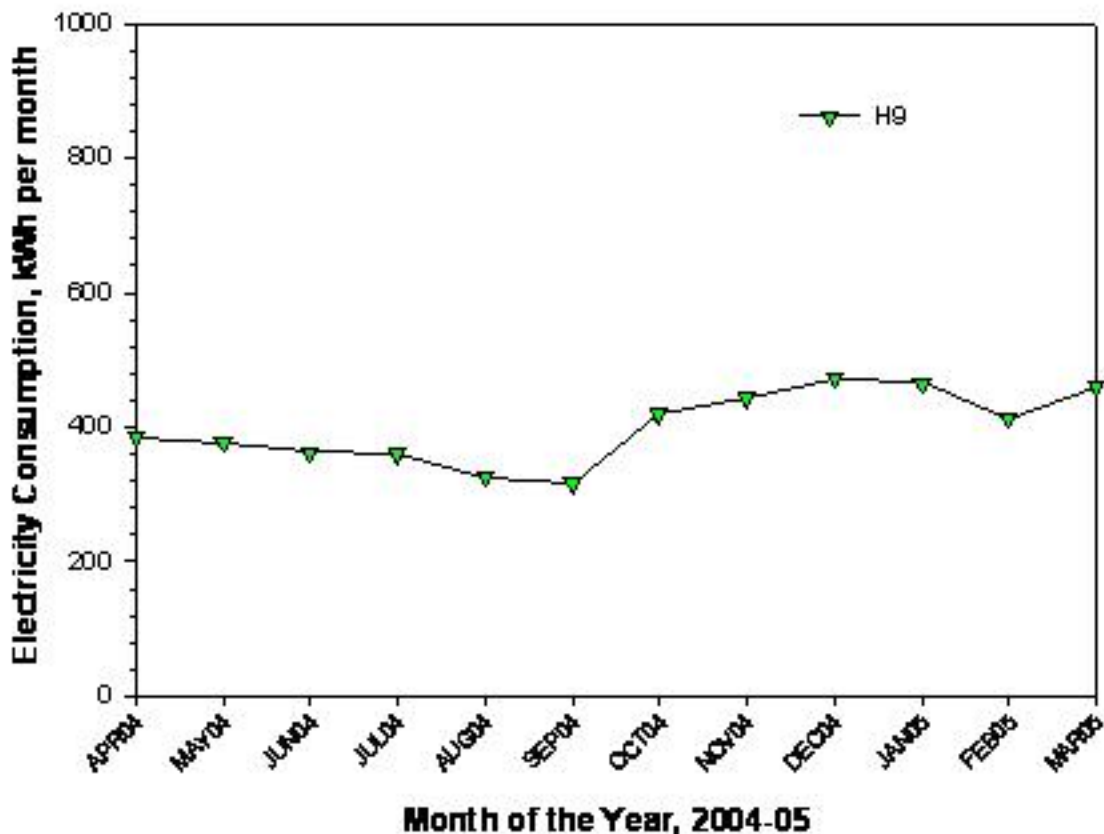
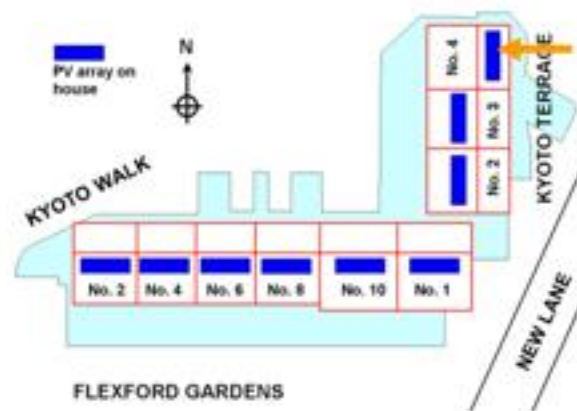
Micro-generation Case Study

Policy Changes



New Lane, Havant

Monthly Electricity Consumption, H9 April 2004..Mar 2005



Opportunities & Barriers

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Micro-Wind

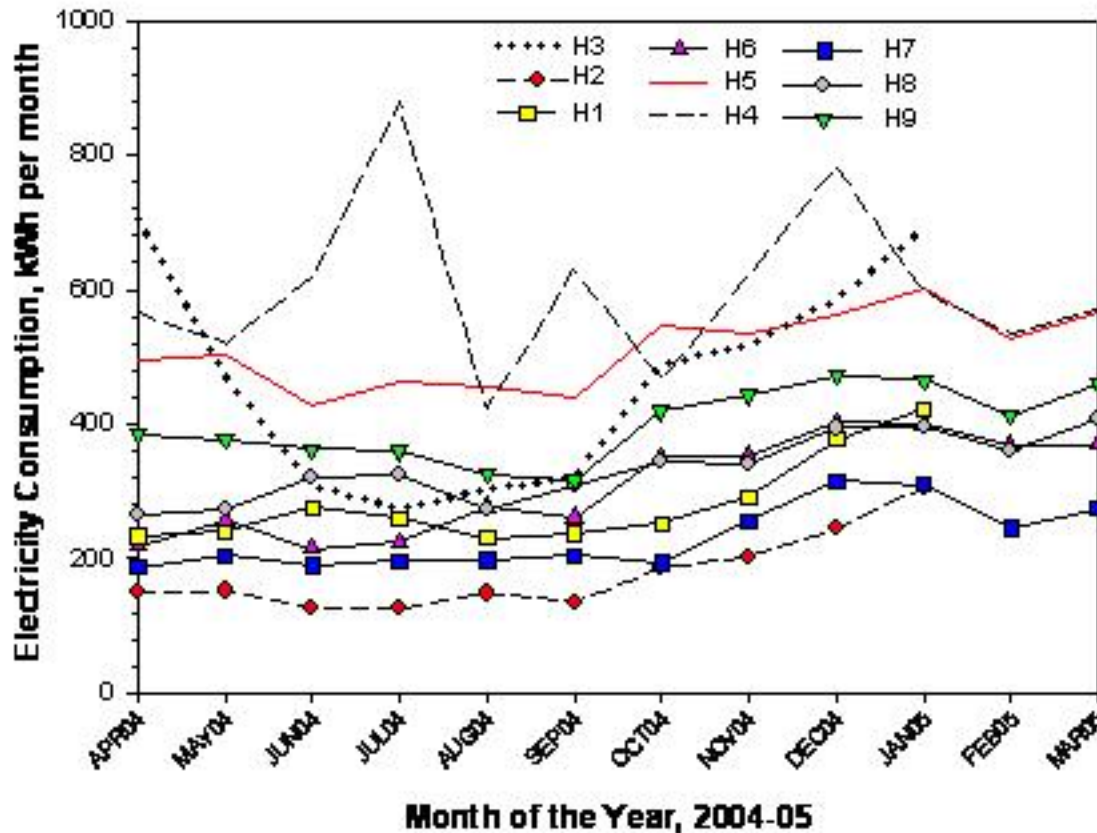
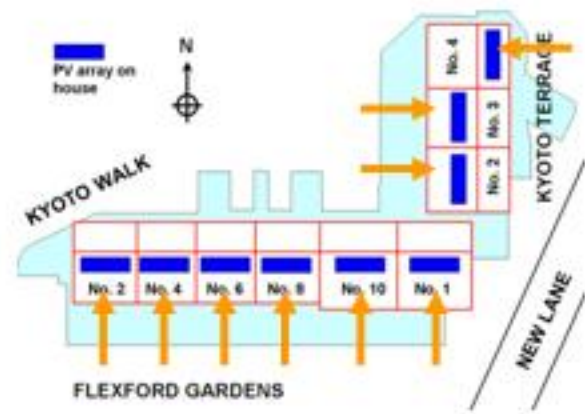
Micro-PV

Micro-generation Case Study

Policy Changes

New Lane, Havant

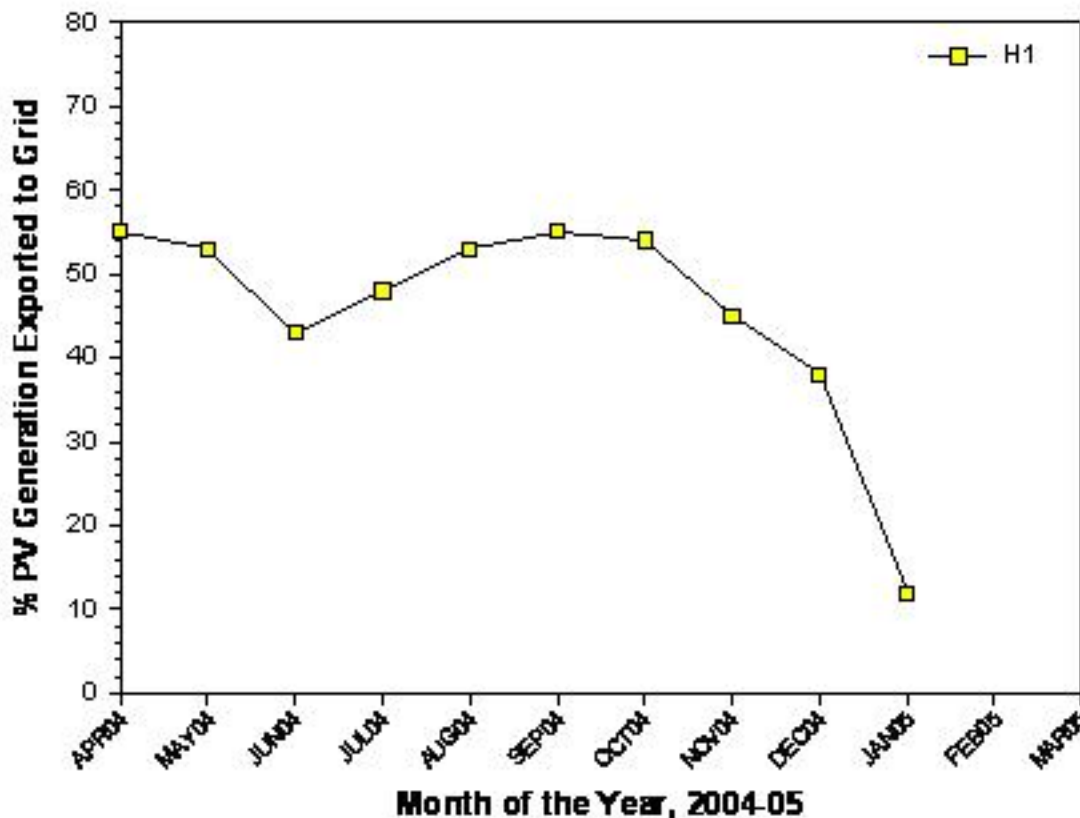
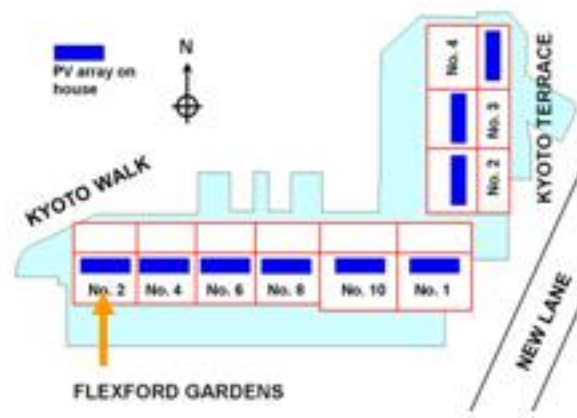
Monthly Electricity Consumption, H1..H9 April 2004..Mar 2005





New Lane, Havant

Monthly Electricity Export, H1 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

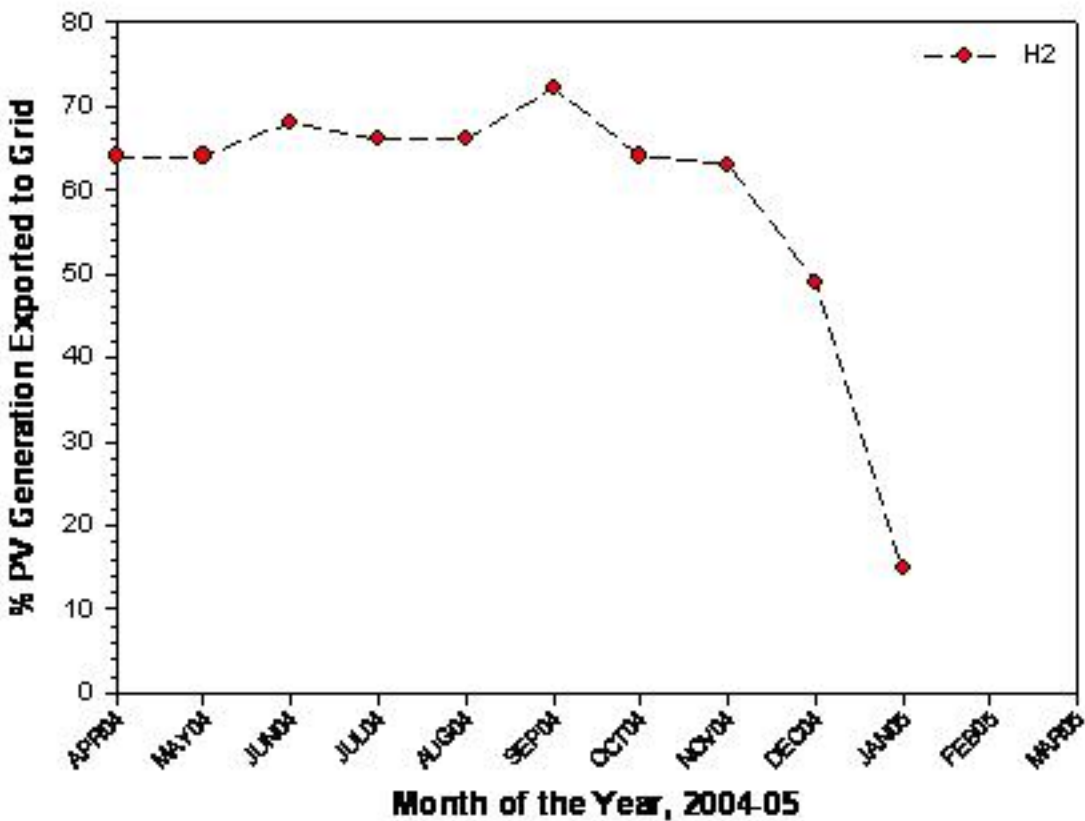
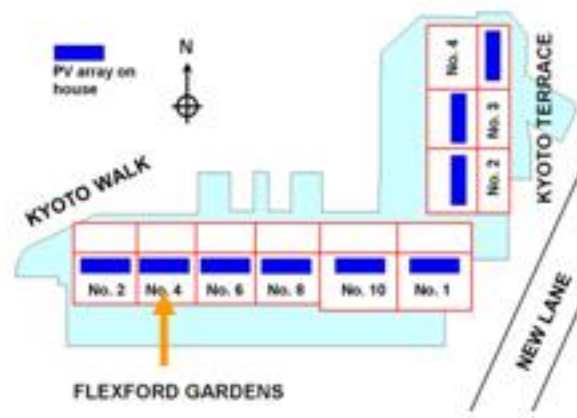
Micro-generation Case Study

Policy Changes



New Lane, Havant

Monthly Electricity Export, H2 April 2004..Mar 2005

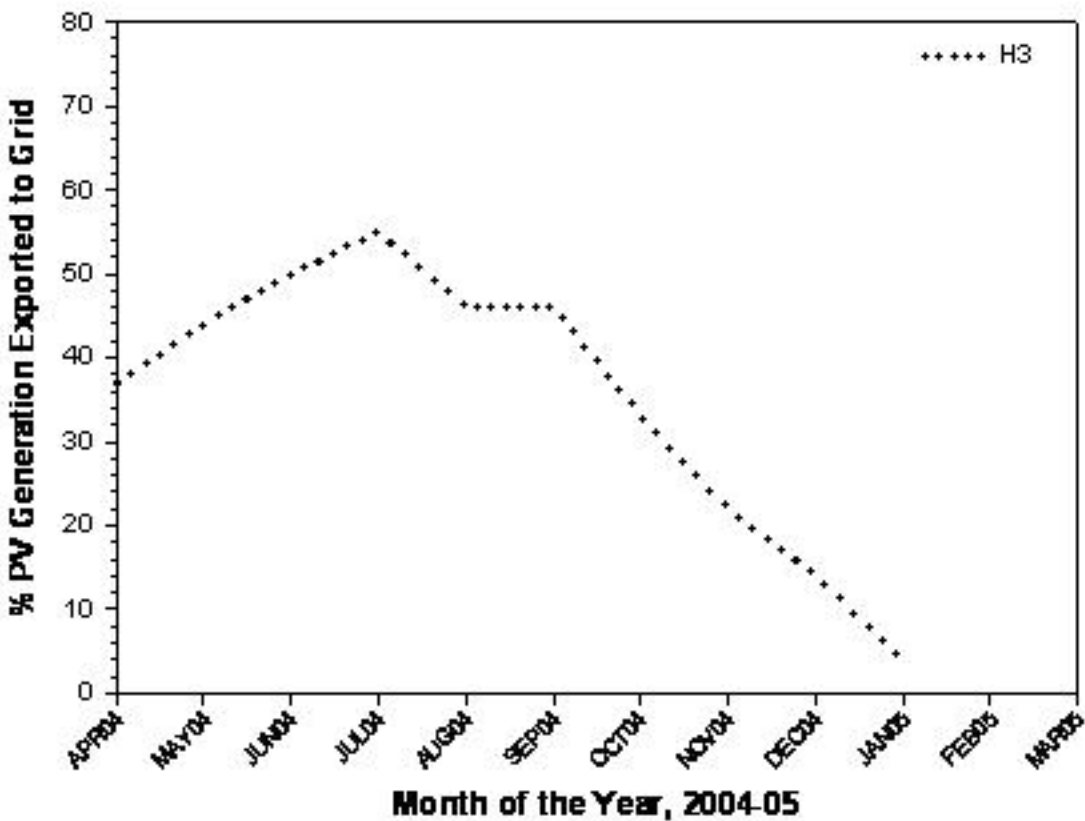
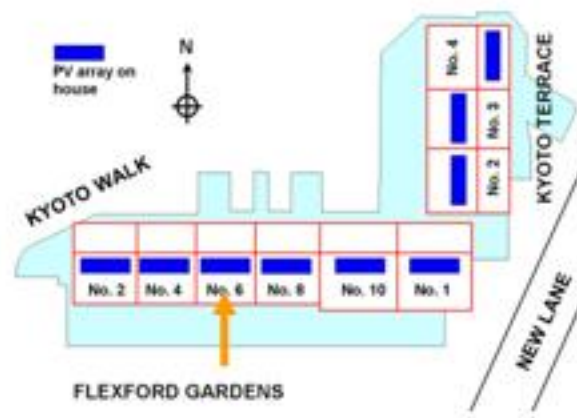


- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



New Lane, Havant

Monthly Electricity Export, H3 April 2004..Mar 2005

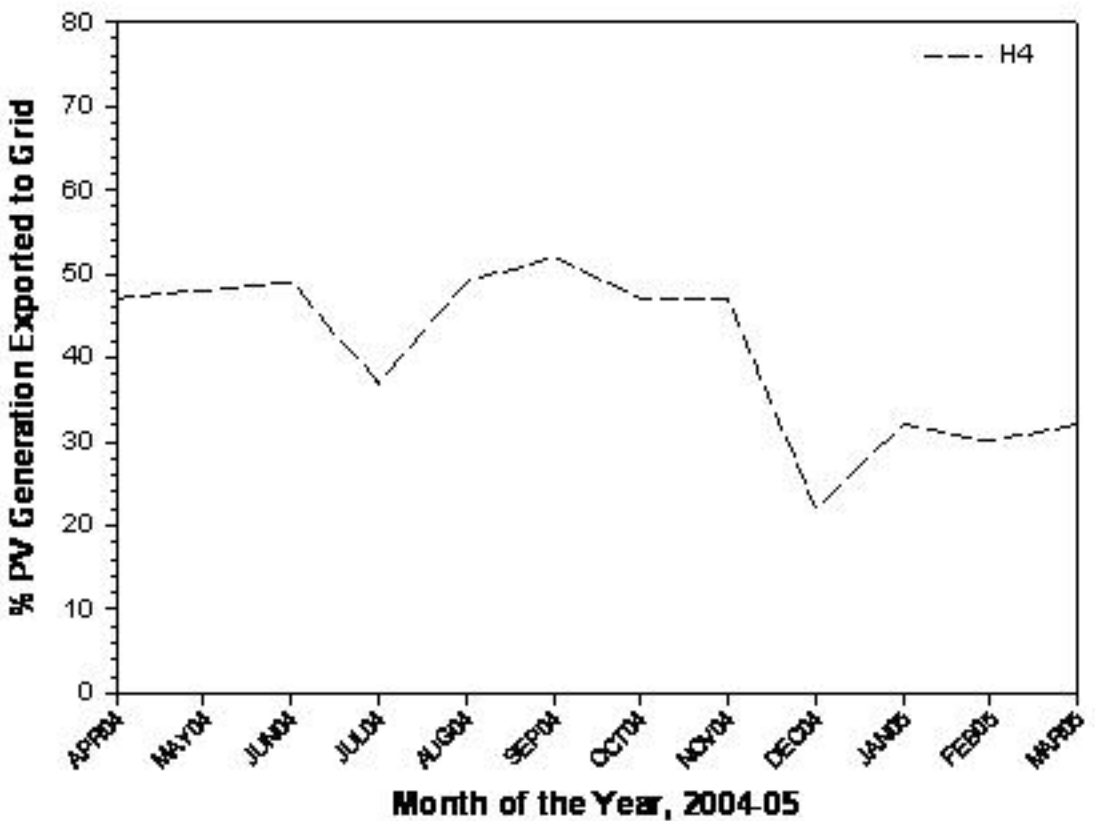
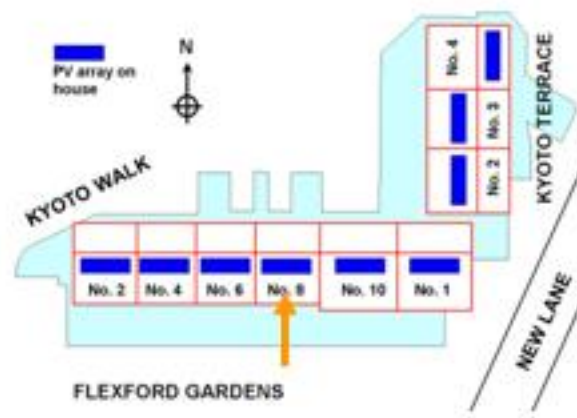


- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



New Lane, Havant

Monthly Electricity Export, H4 April 2004..Mar 2005

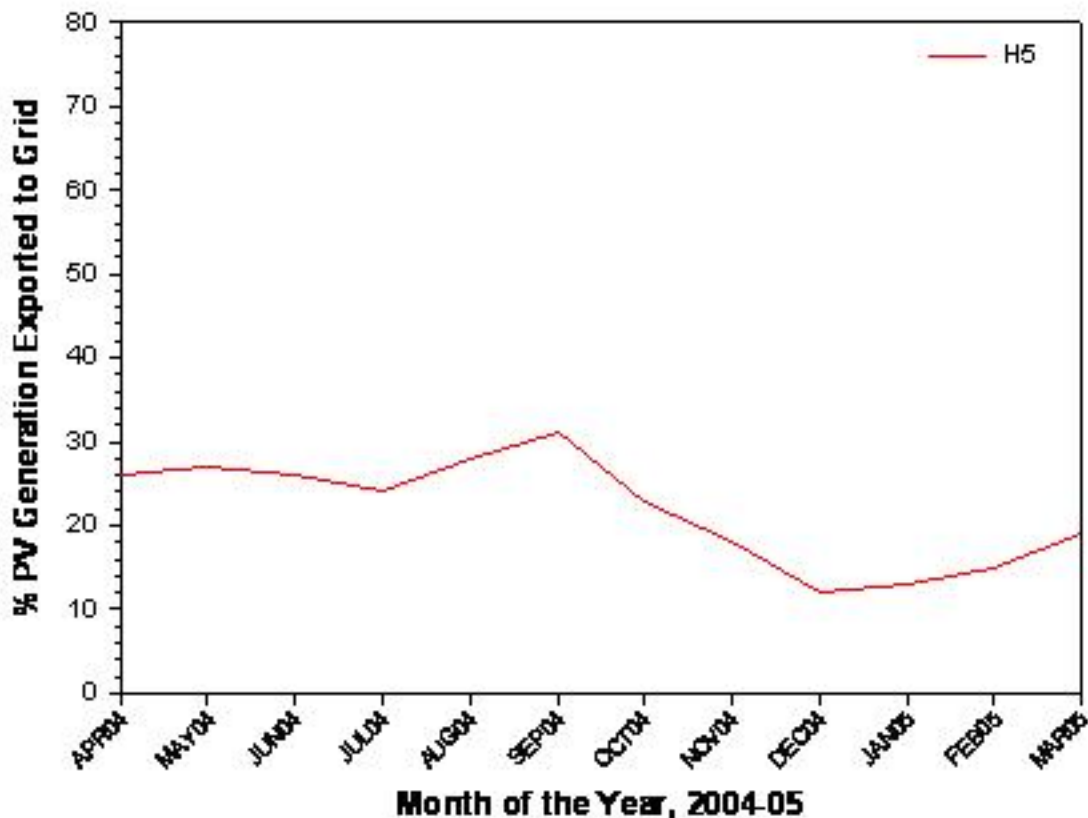
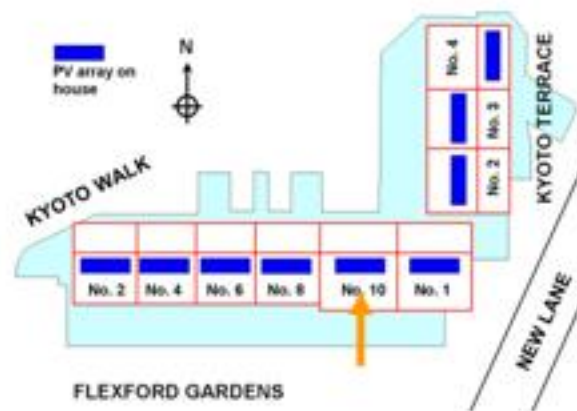


- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



New Lane, Havant

Monthly Electricity Export, H5 April 2004..Mar 2005



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

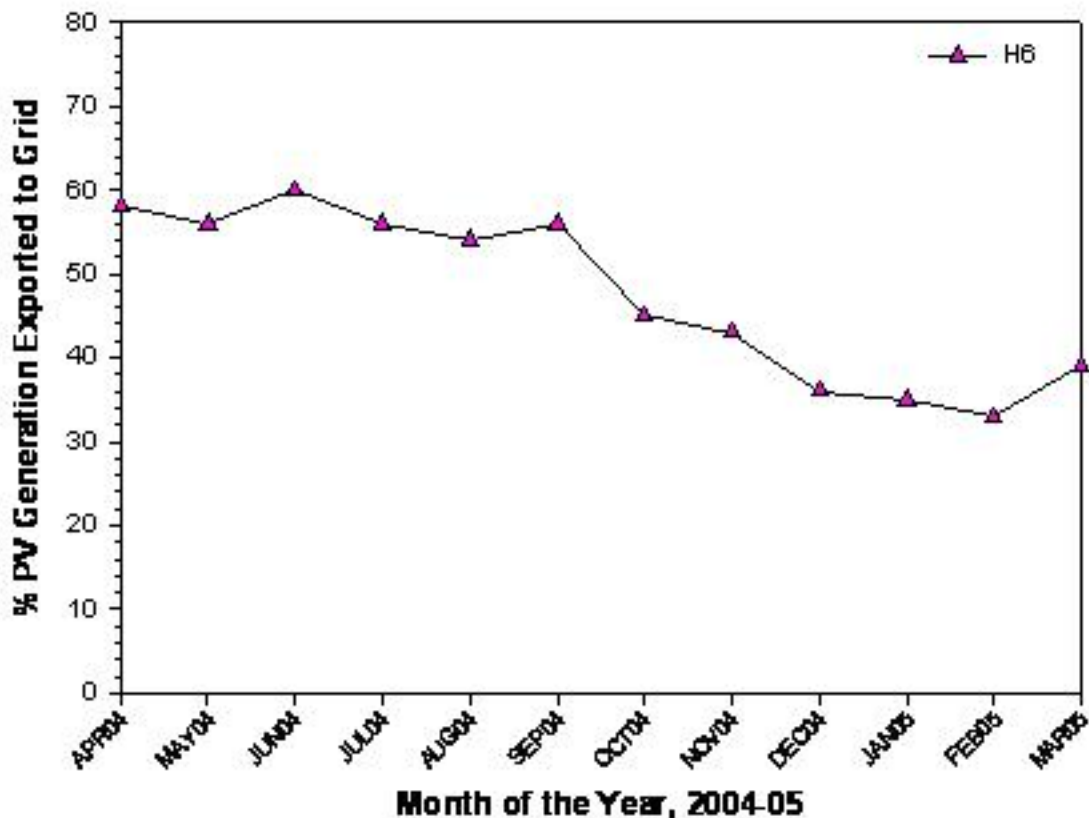
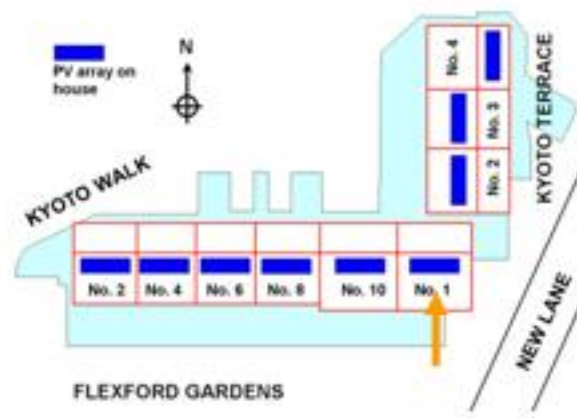
Micro-generation Case Study

Policy Changes



New Lane, Havant

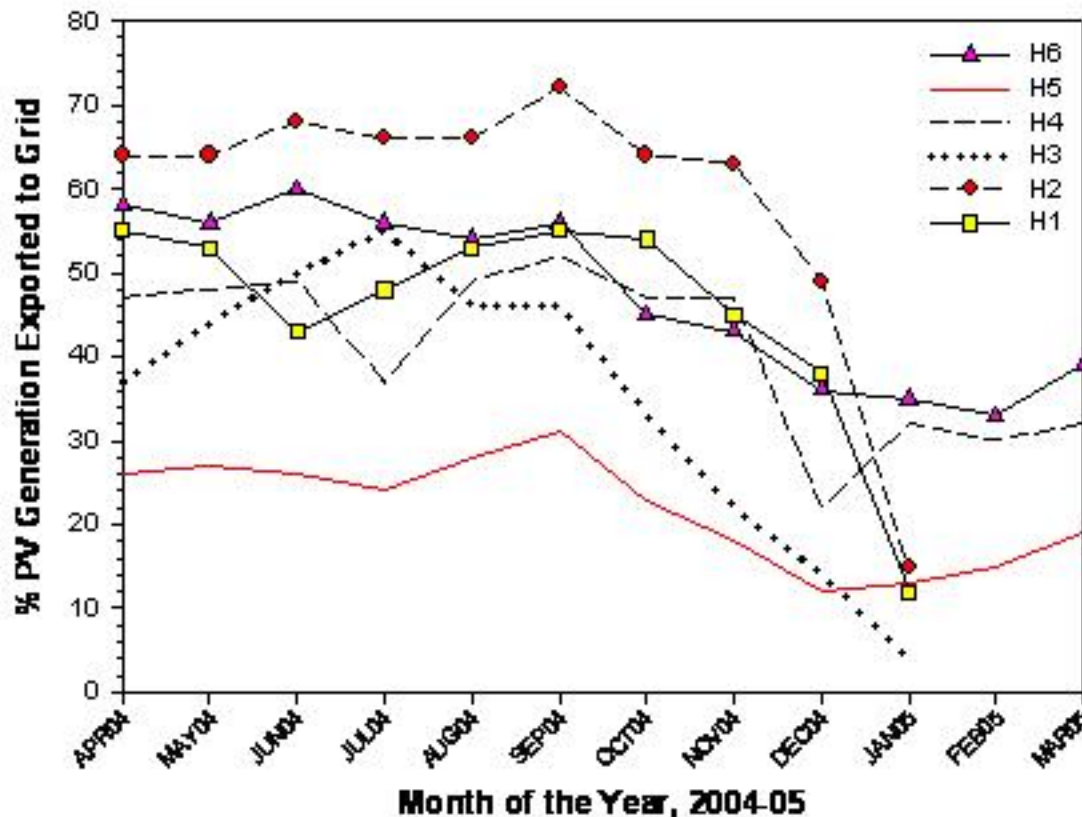
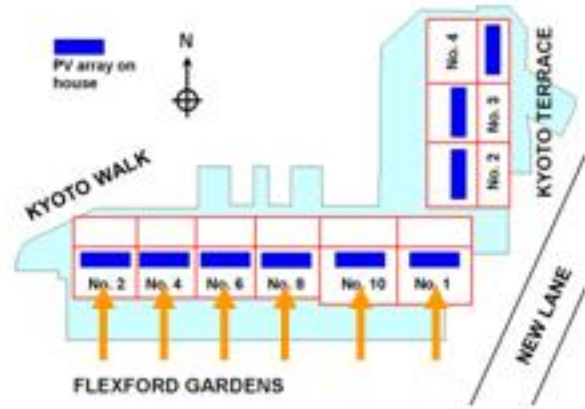
Monthly Electricity Export, H6 April 2004..Mar 2005



- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes

New Lane, Havant

Monthly Electricity Export, H1..H6
April 2004..Mar 2005



Opportunities
& Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

Micro-
generation
Case Study

Policy
Changes



New Lane, Havant

House 2

electricity
consumption

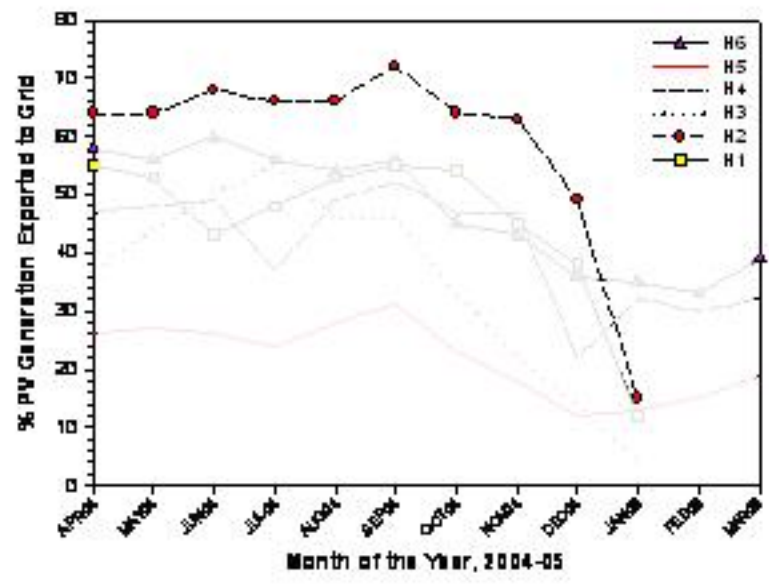
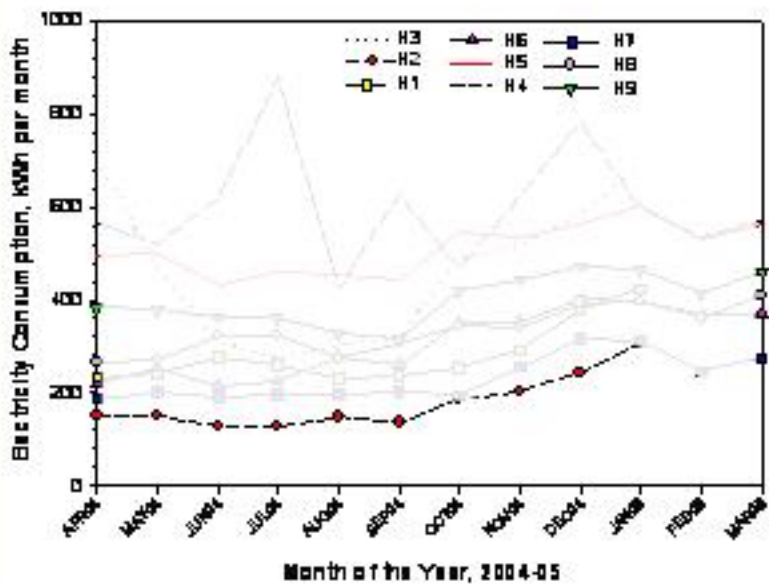
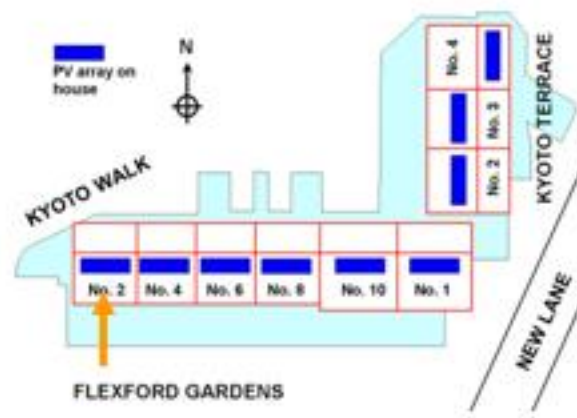
low

exported
electricity

high

'value' generated
electricity

low

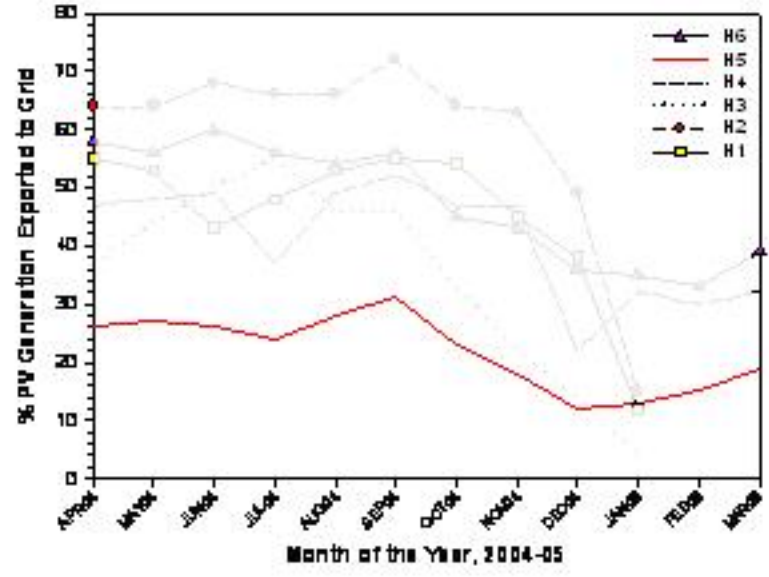
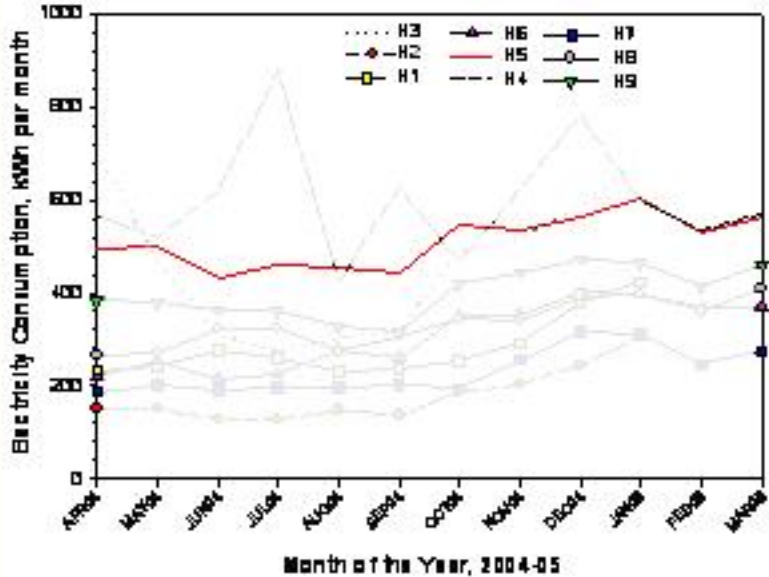
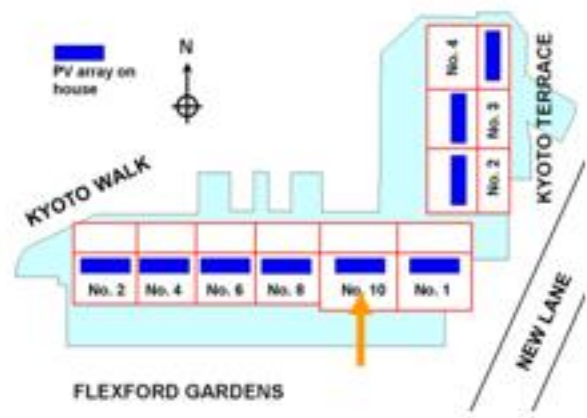


- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



New Lane, Havant

	House 2	House 5
electricity consumption	low	high
exported electricity	high	low
'value' generated electricity	low	high

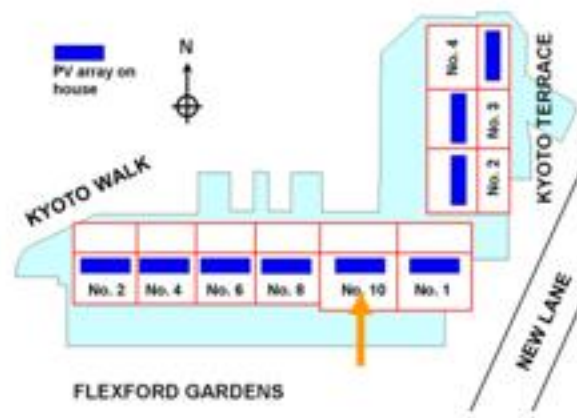


- Opportunities & Barriers
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- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



New Lane, Havant

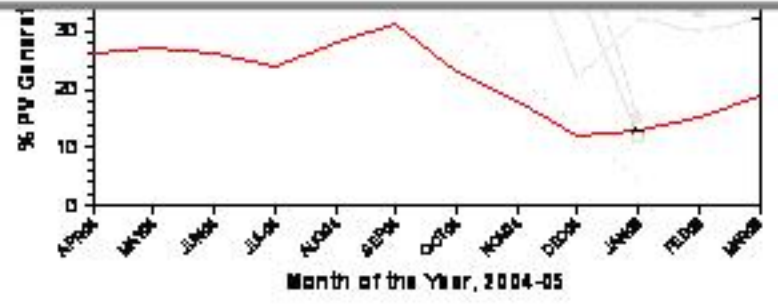
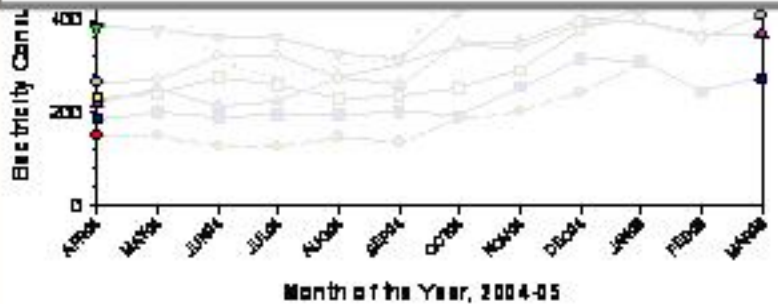
	House 2	House 5
electricity consumption	low	high
exported electricity	high	low



! BEWARE !

Current funding schemes do not encourage energy efficiency!

Is the current practice fair?



- Opportunities & Barriers
- 'The Smiths'
- Micro-CHP
- Micro-Wind
- Micro-PV
- Micro-generation Case Study
- Policy Changes



PV Micro-generation

De-centralised PV generation

PV generation for domestic buildings – generation out of phase with demand.



Opportunities & Barriers

'The Smiths'

Micro-CHP

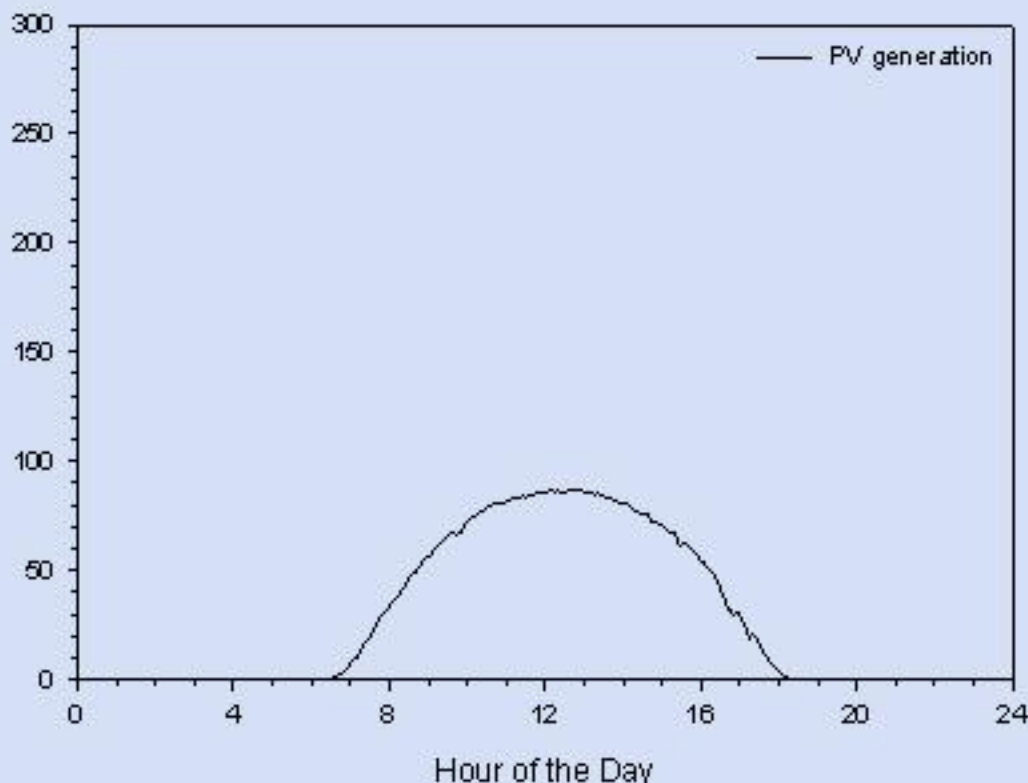
Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes

04/08/04: PV Electricity generation, import, export and demand over 5 minute periods (MWh)



PV generation south facing array on a sunny day

PV Micro-generation

De-centralised PV generation

PV generation for domestic buildings – generation out of phase with demand.



Opportunities & Barriers

'The Smiths'

Micro-CHP

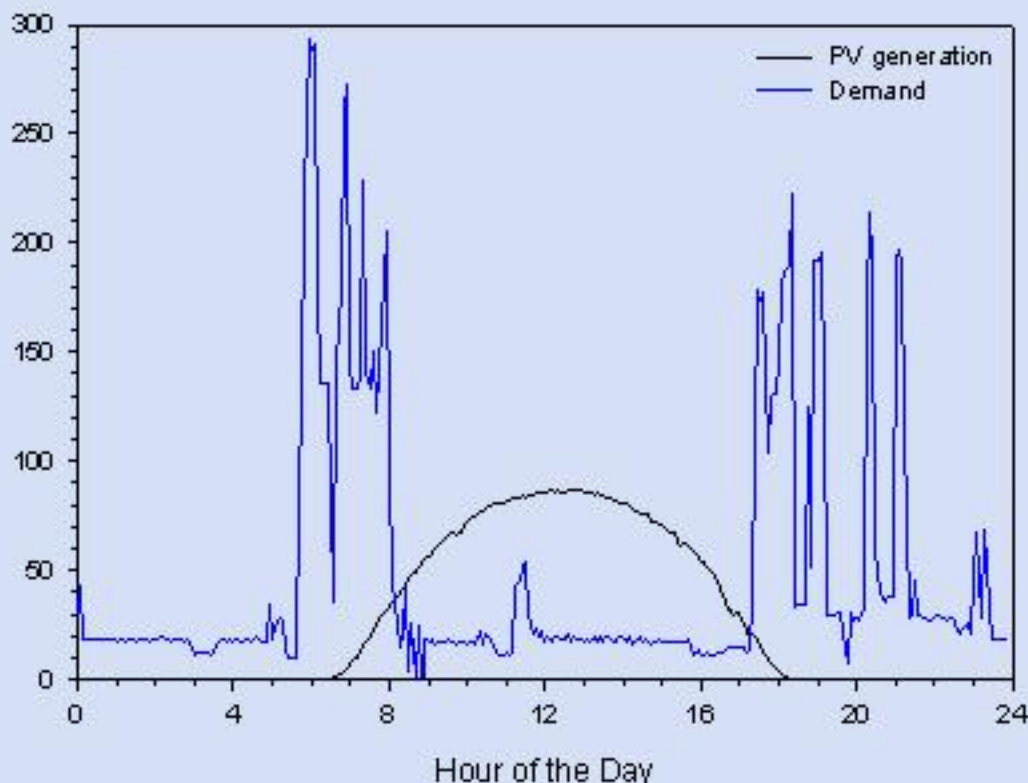
Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes

04/08/04: PV Electricity generation, import, export and demand over 5 minute periods (Wh)



Demand profile of a house within the development

PV Micro-generation

De-centralised PV generation

PV generation for domestic buildings – generation out of phase with demand.



Opportunities & Barriers

'The Smiths'

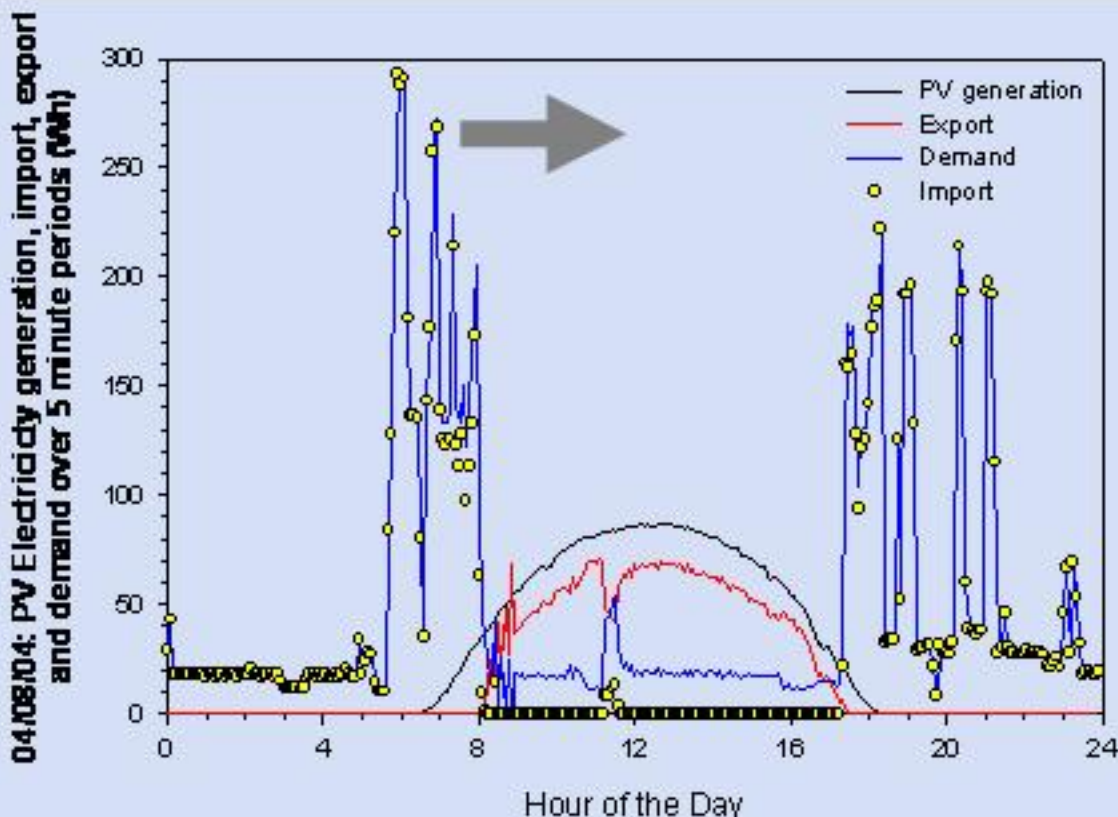
Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes



Load shifting?
Change user behaviour?

=> Improves economics of PV system



Micro-generation : Deployment Models

Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

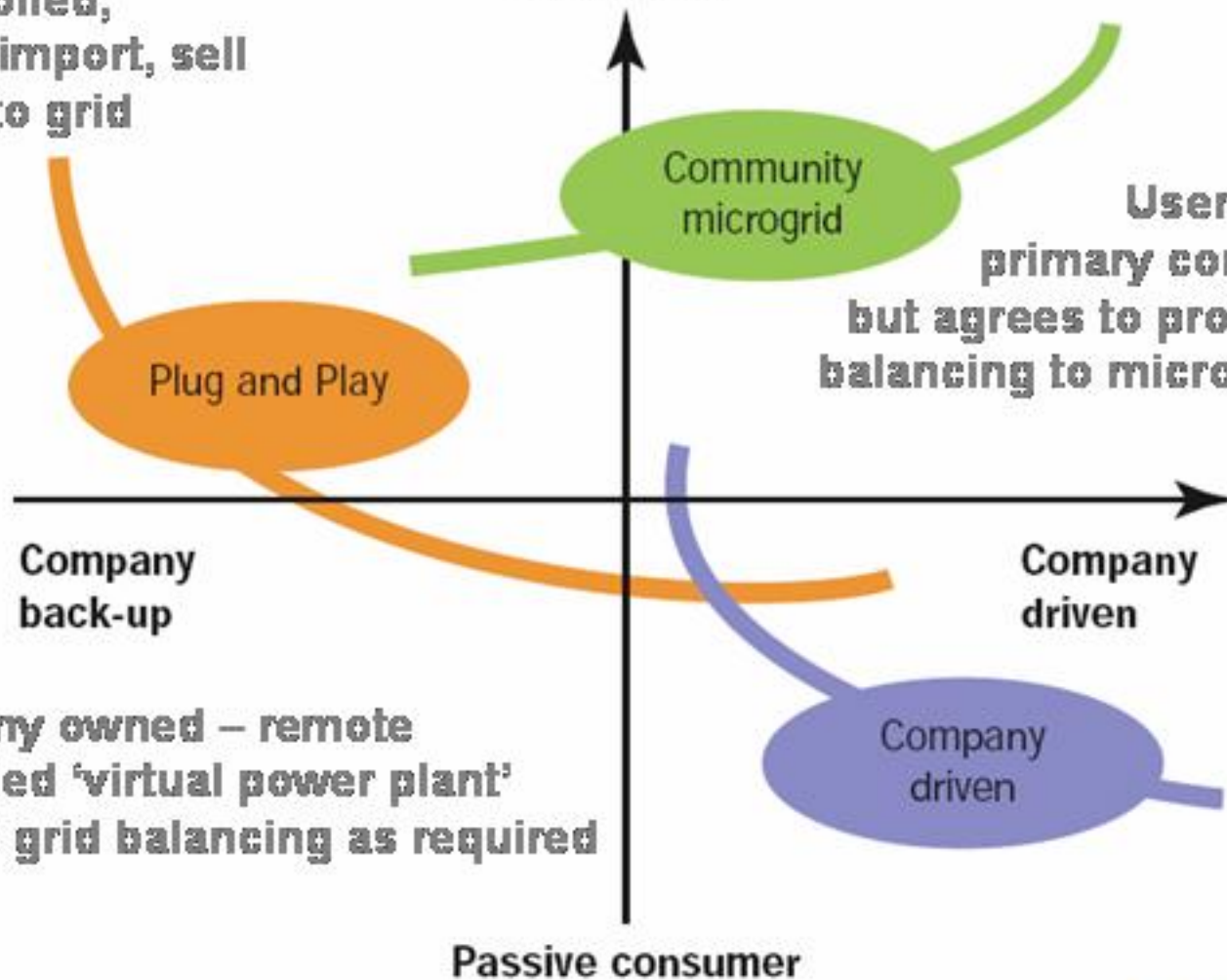
Micro-generation Case Study

Policy Changes

Owner purchased + controlled, reduce import, sell export to grid

Co-provider

User has primary control but agrees to provide balancing to microgrid

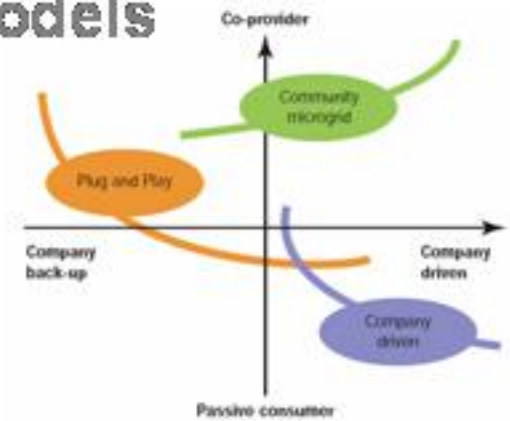


Company owned – remote controlled 'virtual power plant' provide grid balancing as required

Passive consumer



Micro-generation : Deployment Models



Customer perspective	Deployment model		
	Plug and Play	Company Driven	Community Microgrid
Motivations			
Independence	+	-	+/-
Technological interest	+	+/-	+/-
Being green	+	+	+
Hassle free provision	-	+	+/-
Reduced energy bill	+	+	*
Barriers			
Lack of access to capital	+/-	+	+/-
Risk aversion	+/-	+	+/-
Scepticism of new technologies	-	+	+
Lack of information and knowledge	-	+	+

*Depends on the contractual arrangement.

Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes



Micro-generation : Payback Times

Opportunities & Barriers

'The Smiths'

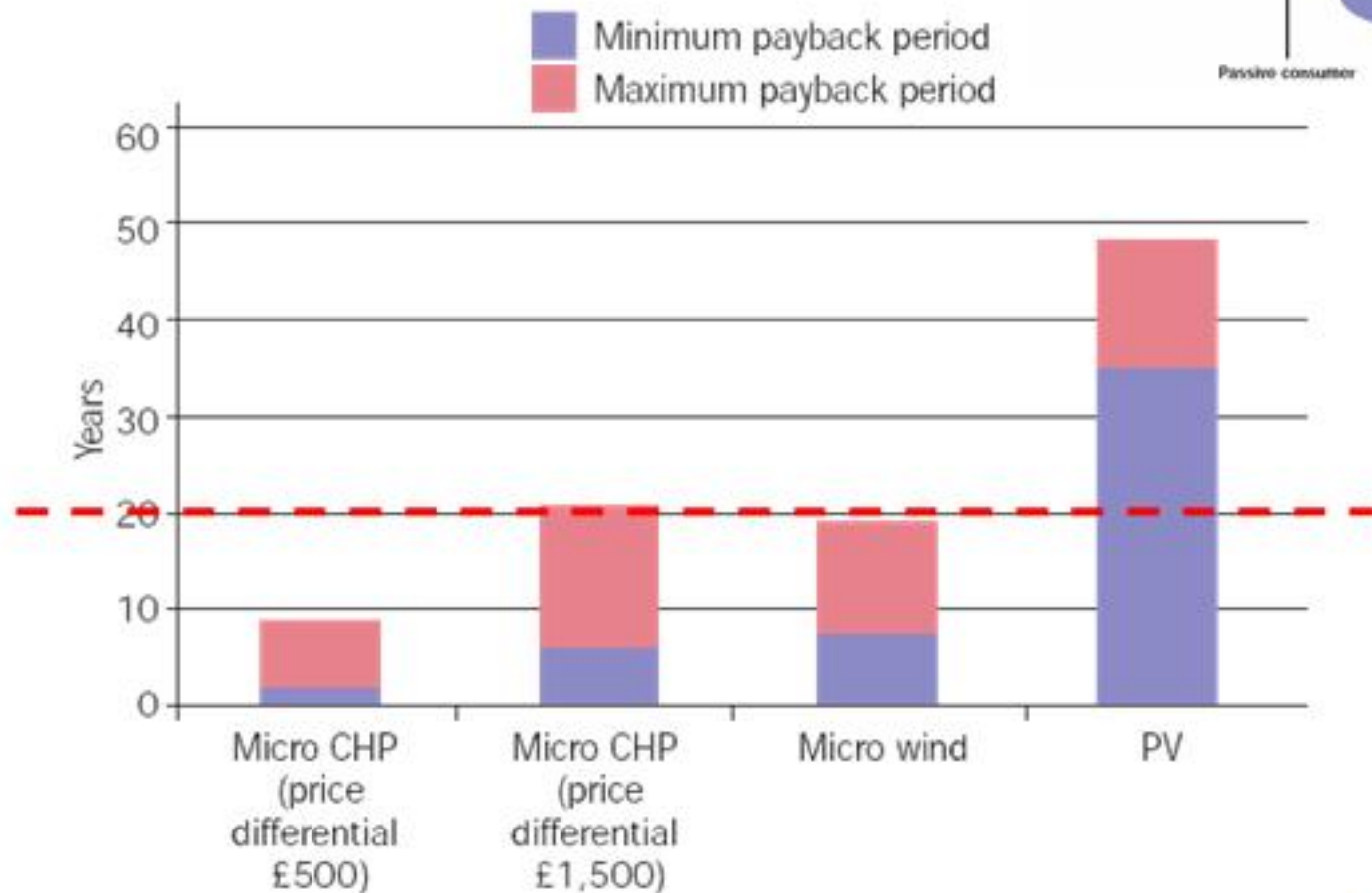
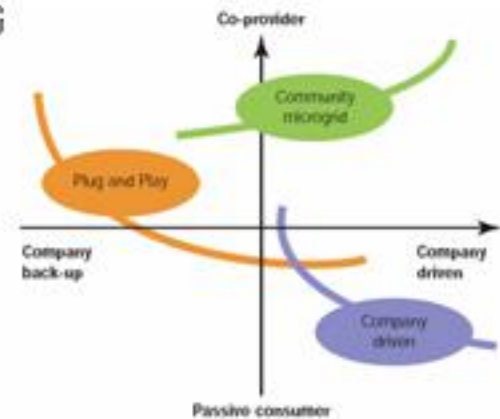
Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes





Micro-generation : Levelling the Playing Field

- 1) **Subsidise capital costs – Low Carbon Buildings Programme**
- 2) **Provide economic reward based on energy production**

**What about anomalies
in the treatment of micro-generation?**

Opportunities
& Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

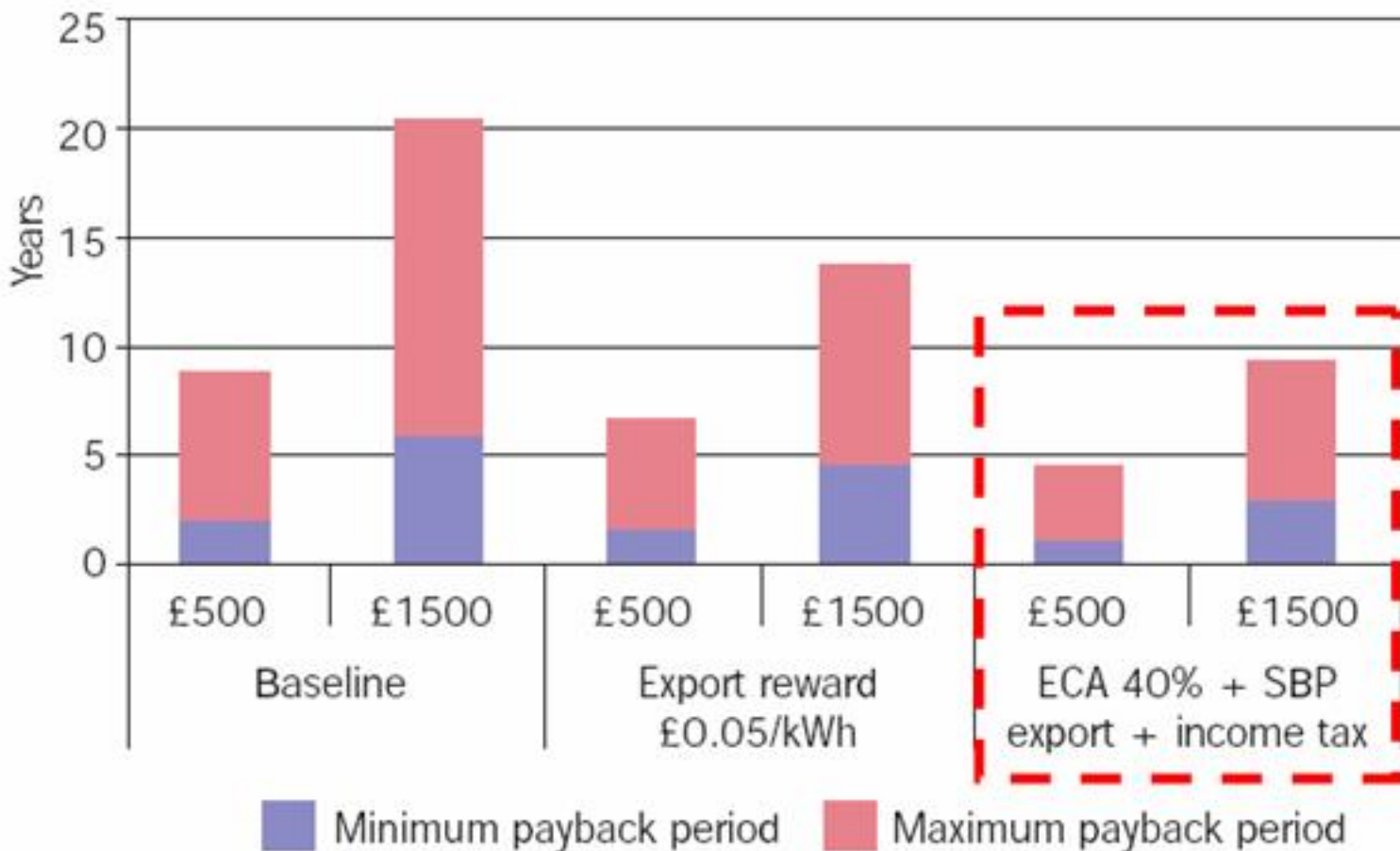
Micro-
generation
Case Study

Policy
Changes



Micro-generation : Levelling the Playing Field

'Plug & Play' : A level playing field for micro-CHP



Opportunities & Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

Micro-generation Case Study

Policy Changes



Summary

**LOAD PROFILE
(User Behaviour)**

**ENERGY
RESOURCE**

But remember ...

People are at the core of the energy issue in buildings. Understanding how people interact with a building is essential to optimise energy usage and generation.

Opportunities
& Barriers

'The Smiths'

Micro-CHP

Micro-Wind

Micro-PV

Micro-
generation
Case Study

Policy
Changes



Unlocking the Power House: Policy and system change for domestic micro-generation in the UK

www.energy.soton.ac.uk/powerhouse

Opportunities
& Barriers

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Micro-CHP

Micro-Wind

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Micro-
generation
Case Study

Policy
Changes



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