Smart Sustainability:

The link between intelligent systems and renewable energy

Dr Bob Howlett

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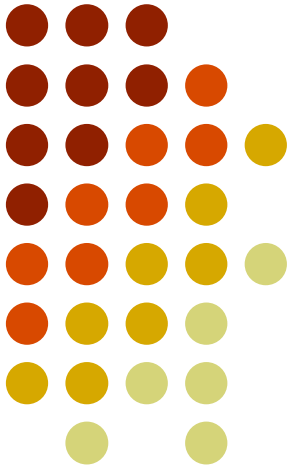

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Sustainable Development

…development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Brundtland report (Our Common Future), United Nations, 1987

…economic development that can be sustained without depleting natural resources or harming the environment

Smart Sustainability

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Apply intelligent systems methods and techniques to

sensing, control, data analysis, prediction and modelling tasks

in sustainability-related areas such as

carbon reduction, energy efficiency, renewable energy generation and related social, environmental and economic factors.

……..Smart Sustainability

Trends in Power Generation

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- Smart Grids: embedded intelligence at various levels in the power network
- Local / Micro-Generation
- Combined Heat and Power (CHP)
- Alternative energy generation using renewable sources

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Power Generation

- Current generation model dates to start of 20th century
- Centralised generation
- Consequent transmission losses
- Poor control of network
- Problems with local generation
- Limited re-routing capability

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Smart Grid Intelligence

Global Intelligence Layer:
- Supervisory Functions

Local Intelligence Layer
- Communcating intelligent agents at sub-station, transformer or building level, monitoring local situation and independently taking action.

Communication Layer
- Bi-directional data-communications using powerline networking, wireless, GPRS/3G/GSM technology

Power infrastructure layer
- Cables, transformers, etc., carrying the power

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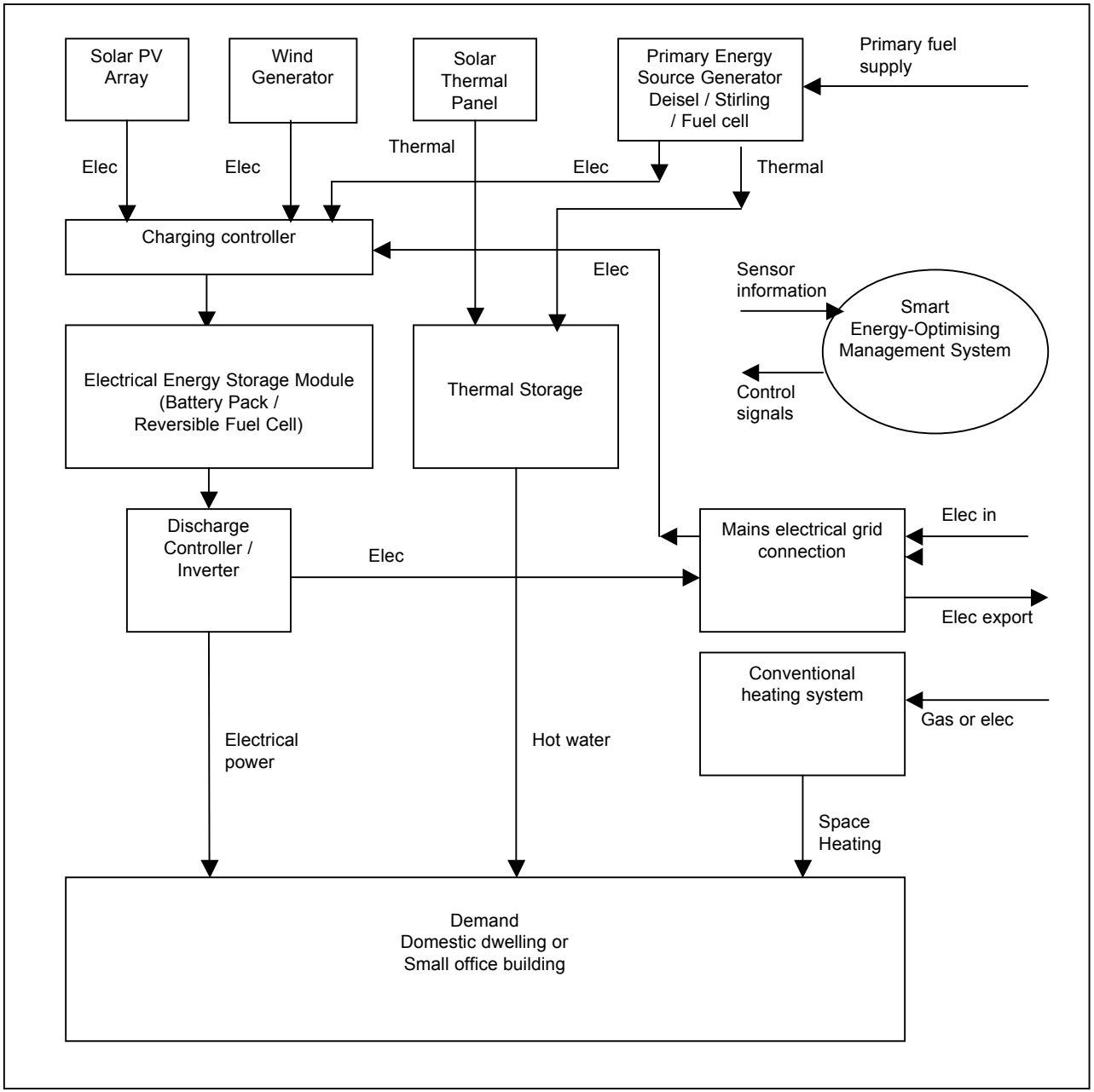
Local Generation in the UK

- 1 - 3 million microgeneration installations together with CO2 savings of 1 and 3 million tonnes by 2020 and 2030 respectively … leading technologies being identified as micro CHP and heat pumps [1].
- Up to 25% of the UK energy supply could be met from microgeneration by 2050, without Government subsidies, based primarily on micro CHP and micro wind [2].
- Other studies have indicated a wide range of potential contributions, with micro CHP alone potentially providing an installed capacity of 12-22GWe.

1. *UK Govt BERR Dept report 2008*
2. *Energy Saving Trust UK report 2005*



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Hybrid Micro-Generation System

Hybrid Micro-Generation System - Simulation

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- Model hybrid renewable energy micro-generation system + demand side (buildings)
- Develop optimal control and scheduling strategies
- Determine best mix of renewable and conventional energy sources
- Renewable energy system CAD

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Photo Voltaic Panels

Generate electric power from incident (sun) light energy

Efficiency approx 12% -18%

Smart PV Panel Architecture

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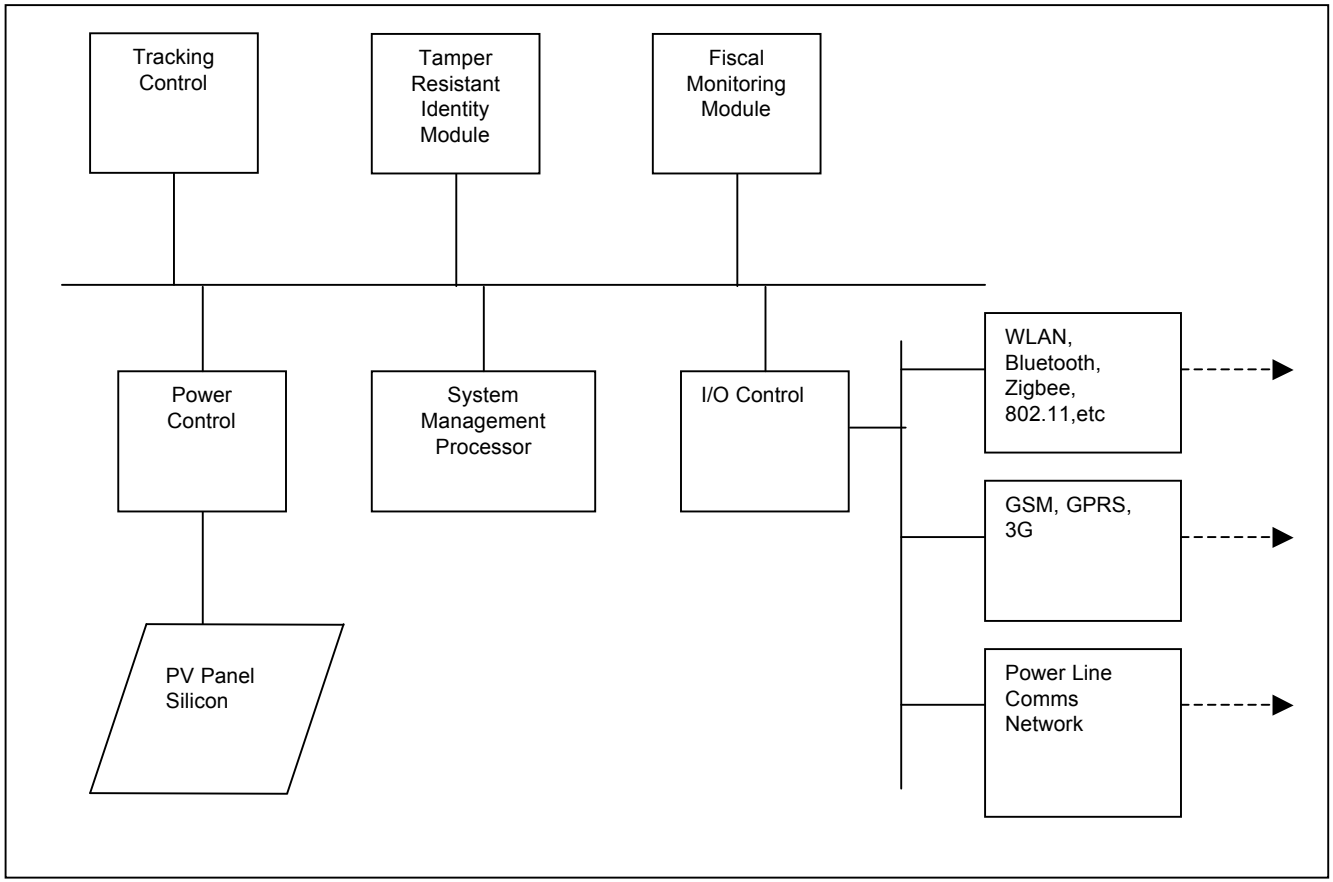

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Smart Photo-Voltaic Panel

Sun Tracking Fuzzy System

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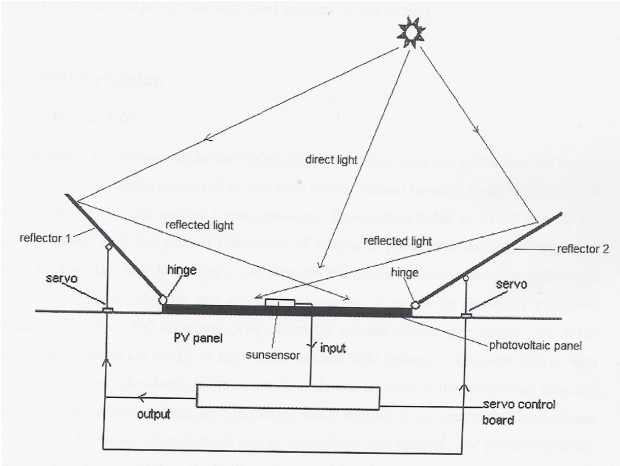

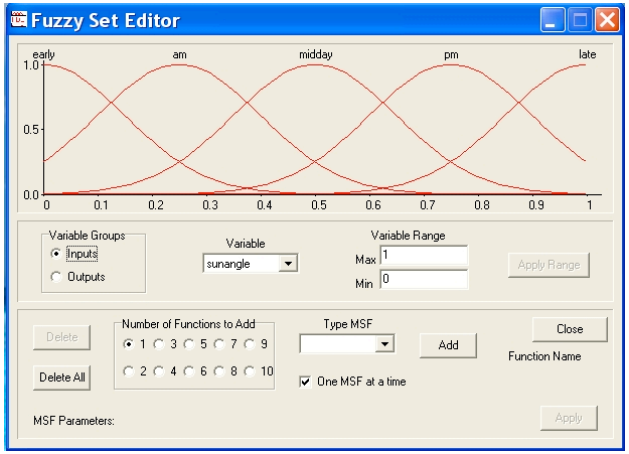

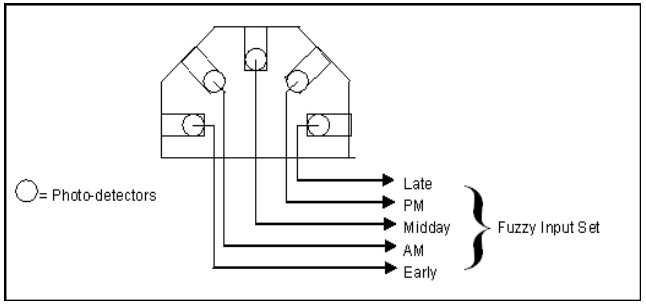

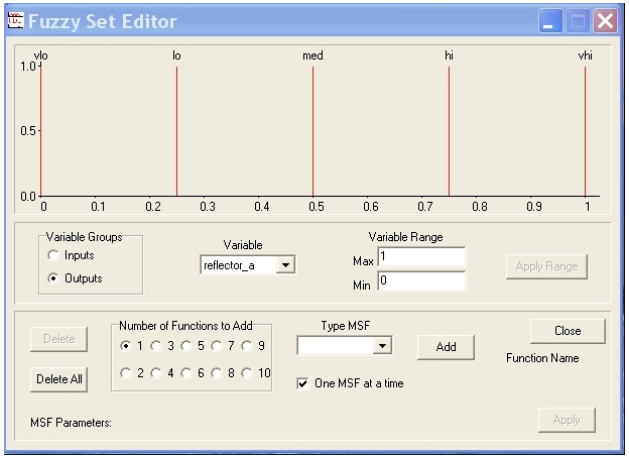

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Fuzzy Rule Base

Main Rule-Set

IF sun_sensor=early THEN a_angle=v_lo AND b_angle=v_hi
IF sun_sensor=AM THEN a_angle=lo AND b_angle = hi
IF sun_sensor=midday THEN a_angle=med AND b_angle=med
IF sun_sensor=PM THEN a_angle=hi AND b_angle=lo
IF sun_sensor=late THEN a_angle=v_hi AND b_angle=v_lo

Supplementary Rule-Set

IF sun_sensor=AM AND sun_sensor=midday THEN a_angle=lo AND b_angle=high
IF sun_sensor=midday AND sun_sensor=pm THEN a_angle=high AND b_angle=lo
IF sun_sensor=AM AND sun_sensor=midday AND sun_sensor=pm
THEN a_angle=med AND b_angle=med

Smart PV Panel : Lab Performance

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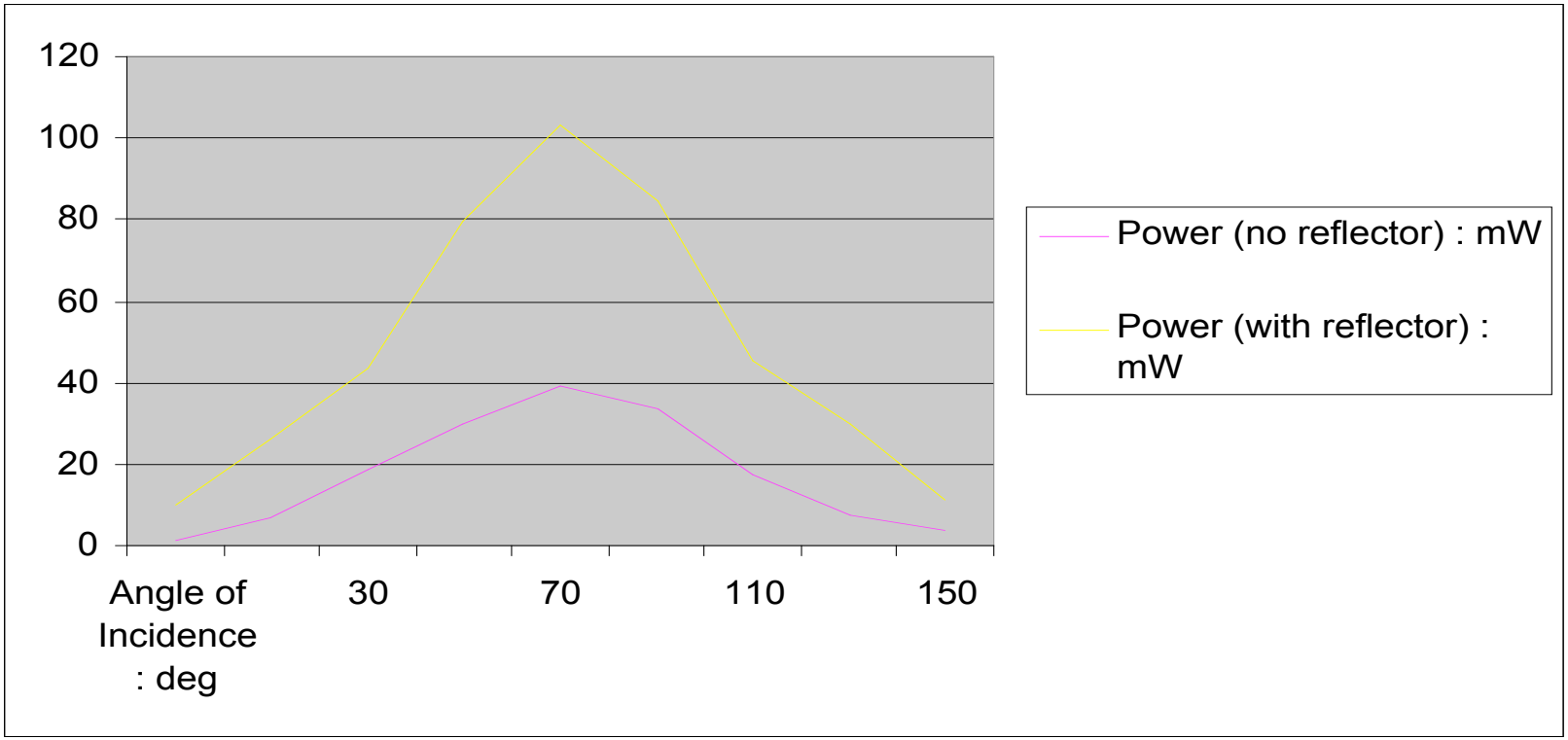

Primary Energy Source Generation System

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- Generate electrical and thermal energy from liquid fuel.
- Combined heat and power - CHP
- Utilise bio-fuels e.g. bio-diesel, bio-ethanol, etc. natural gas… hydrogen…?
- Base on commonly available spark-ignition or diesel engine units
- Aim for high efficiency, low emissions and low cost

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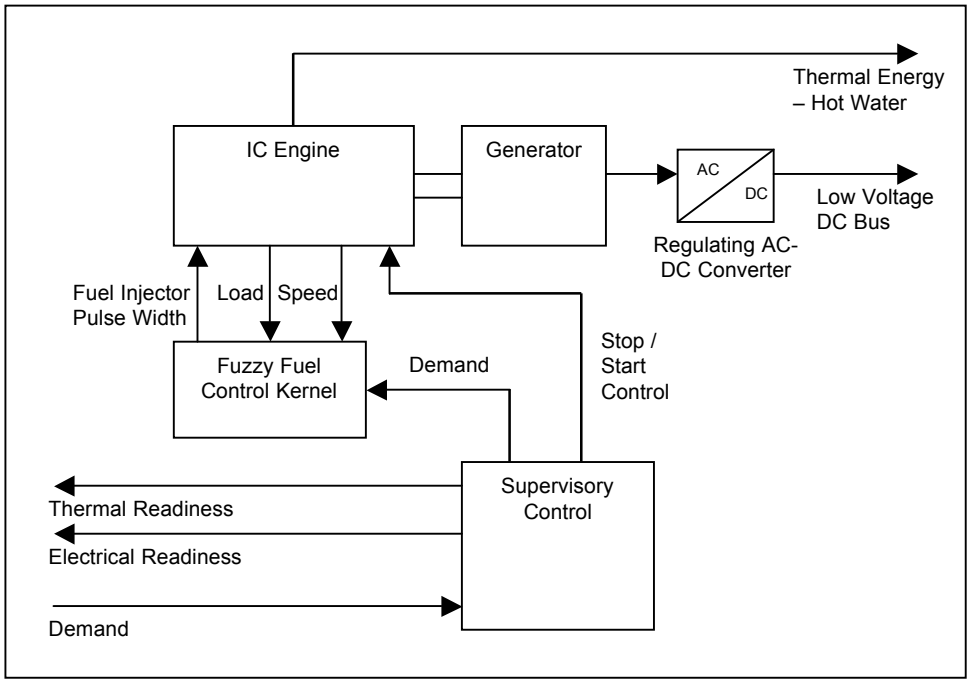

Calibration

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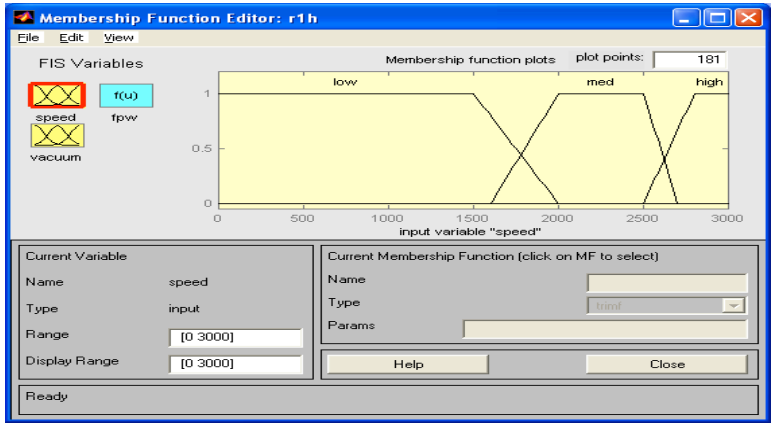

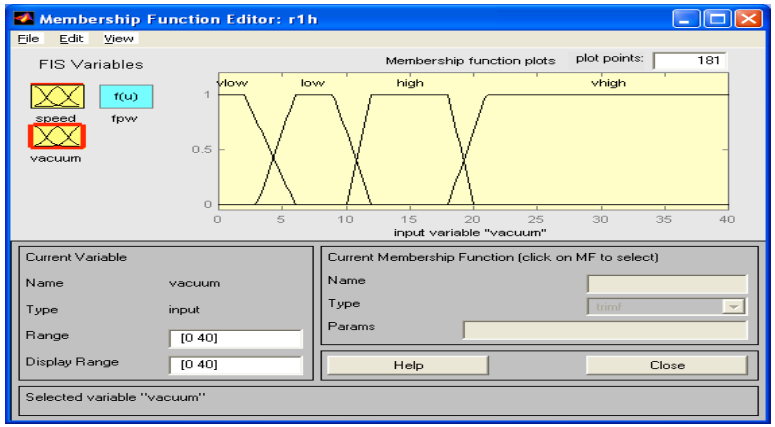

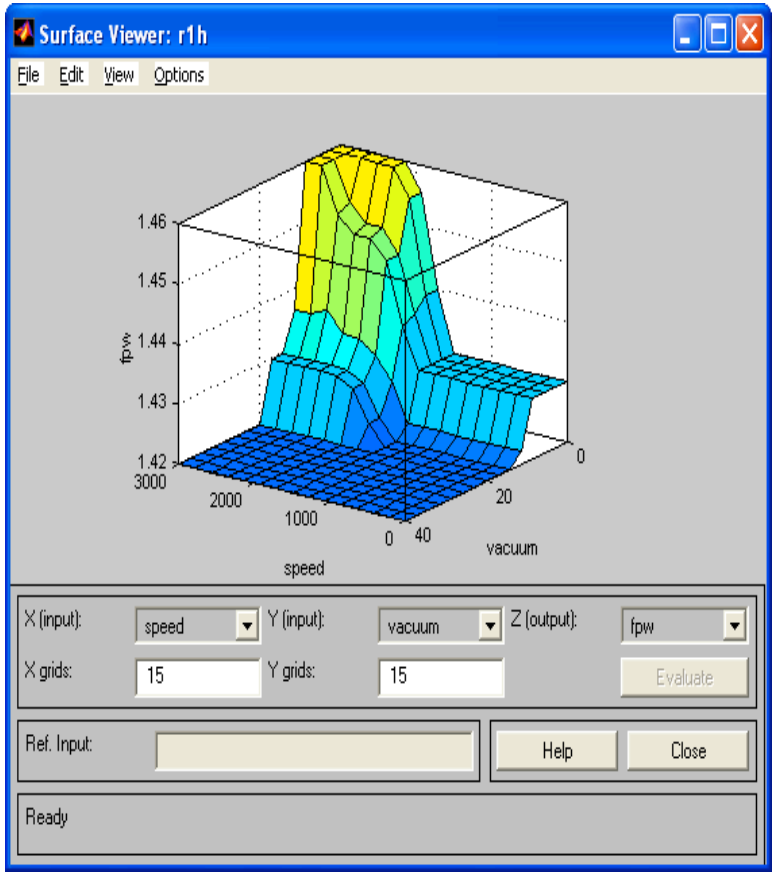

Power and Torque (50% TPS)

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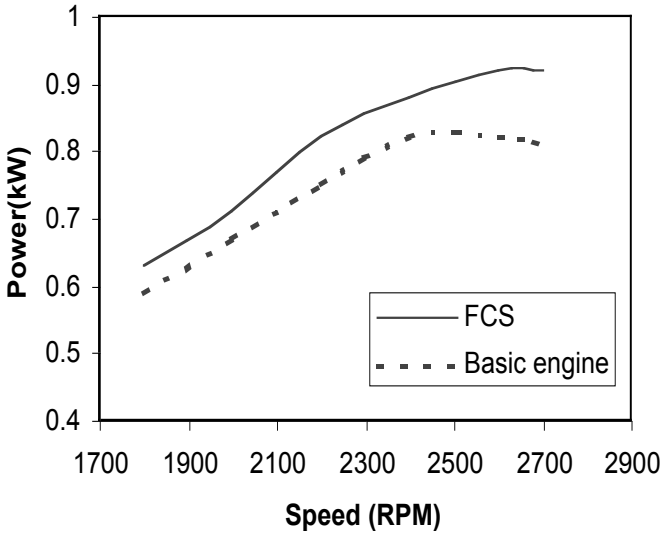

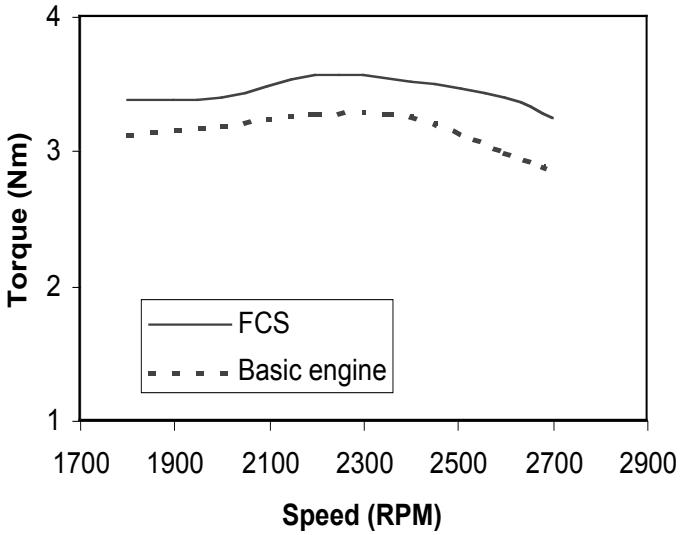

Emissions

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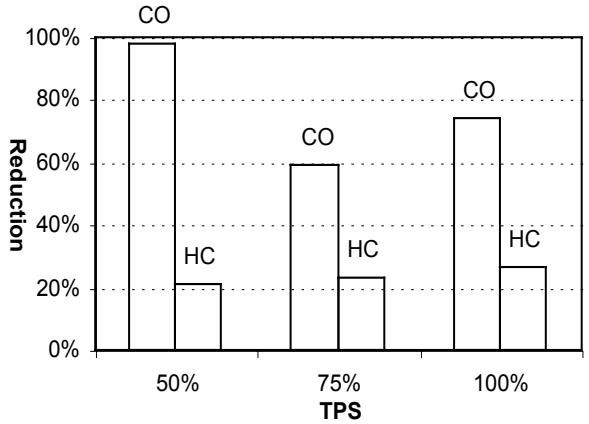
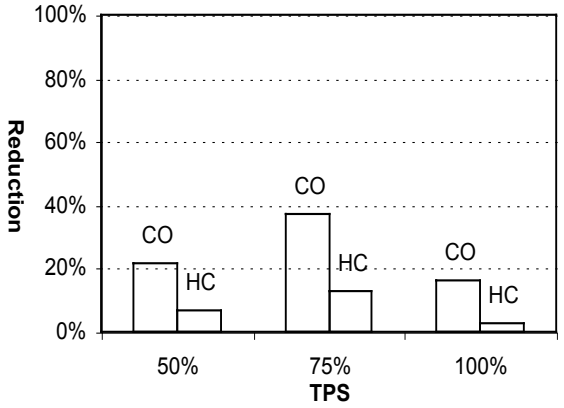


Emissions reduction at 1800 RPM



Emissions reduction at 2200 RPM

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Conclusions

- Incorporation of computational intelligence in the generation system an important trend
- Microgeneration and local generation
- Computer-based simulation and modelling of energy systems
- Control strategies and scheduling
- CAD of renewable energy systems