Energy Management System for Fuel Cells

Best available technologies & future fast progress of Micro-CHP in conjunction with Renewable Energy

European Workshop in Petten
6th of April, 2006
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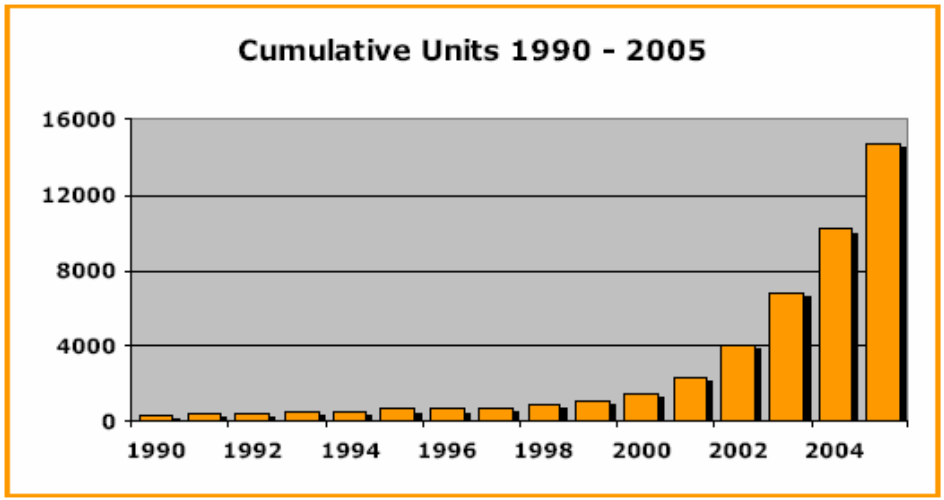


Source: Fuel Cell Today 2005 Worldwide Survey

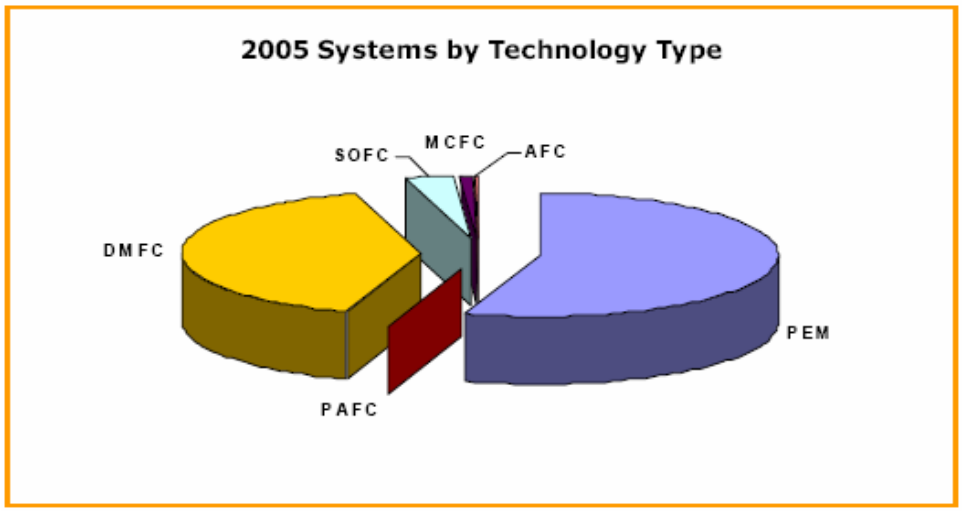
Stationary applications / Combined Heat and Power / MicroCHP

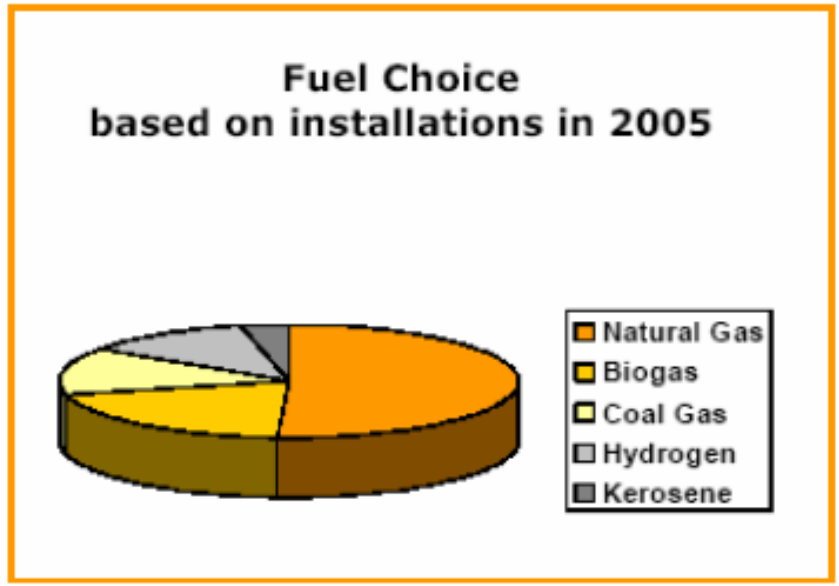
- **Sales projection 2020**
  - 100.000-200.000 Units or 2-4 GW per year (large, medium and microCHP)
- **Market launch for MicroCHP**
  - expected 2010-2015,
  - market growth 2015-2020
- **Cost projection for MicroCHP**
  - 2000 Euro per kW (Target 2020)
  - 4000 Euro per kW (Target 2010)

Source: European Hydrogen & Fuel Cell Technology Platform - Second Annual Event -, Joachim Berg, Vaillant GmbH

Fuel Cells – Technology & Fuel

Market dominated by PEMFC technology, especially in car industry
NG still most common fuel, share of anaerobic digester gas and coal gas growing





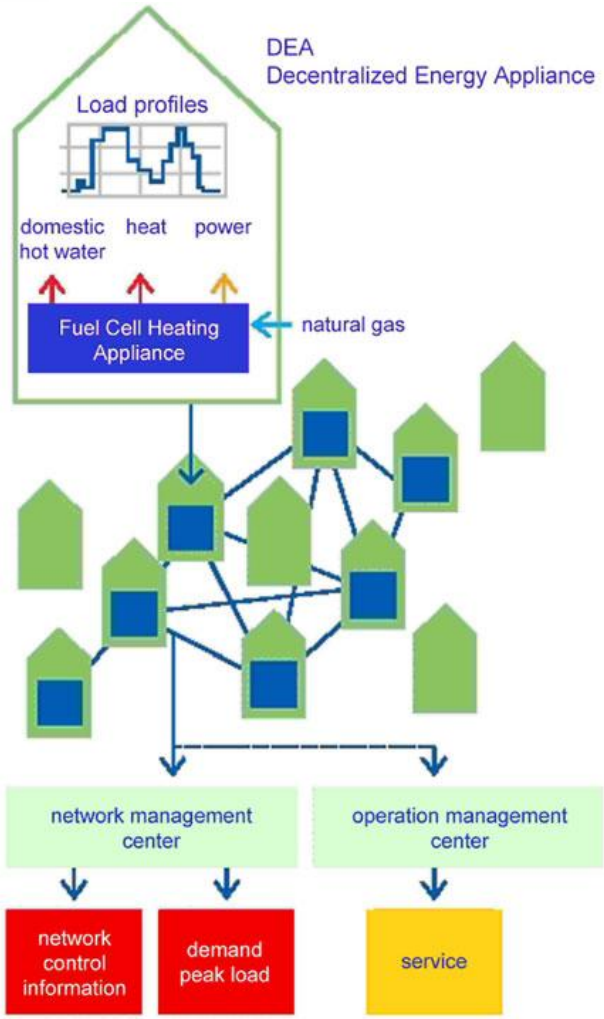
Source: Fuel Cell Today 2005 Worldwide Survey

Fuel Cells – Characteristics

	AFC	DMFC	MCFC	PAFC	PEMFC	SOFC
Electrolyte	Potassium hydroxide	Polymer membrane	Immobilised Liquid Molten Carbonate	Immobilised Liquid Phosphoric Acid	Ion Exchange Membrane	Ceramic
Operating Temperature	60-90ºC	60-130ºC	650ºC	200ºC	80ºC	1,000ºC
Efficiency	45-60%	40%	45-60%	35-40%	40-60%	50-65%
Typical Electrical Power	Up to 20 kW	< 10 kW	> 1 MW	> 50 kW	Up to 250 kW	> 200 kW
Possible Applications	Submarines, spacecraft	Portable applications	Power stations	Power stations	Vehicles, small stationary	Power stations

Source: Fuel Cell Today; www.fuelcelltoday.com

Virtual Power Plant (VPP)

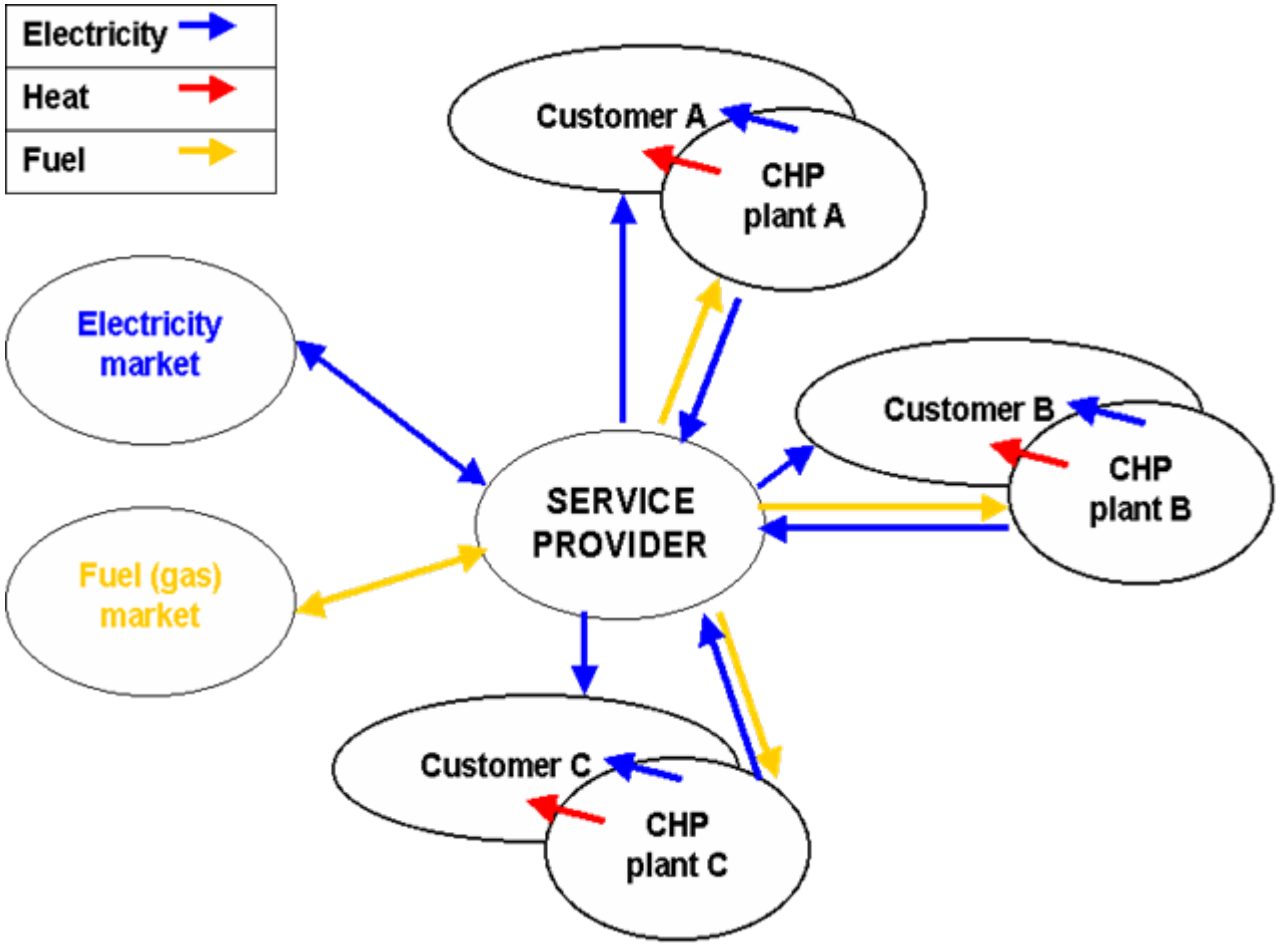


The Virtual Fuel Cell Power Plant is a **series of decentralized residential micro-CHP's** using fuel cell technology, installed in multi-family-houses, small enterprises, public facilities etc., for individual heating, cooling and electricity production. **Centrally controlled and grid-connected**, these elements of the virtual power plant contribute to meet peaking energy demand in the public electricity grid and act as a virtual power plant.

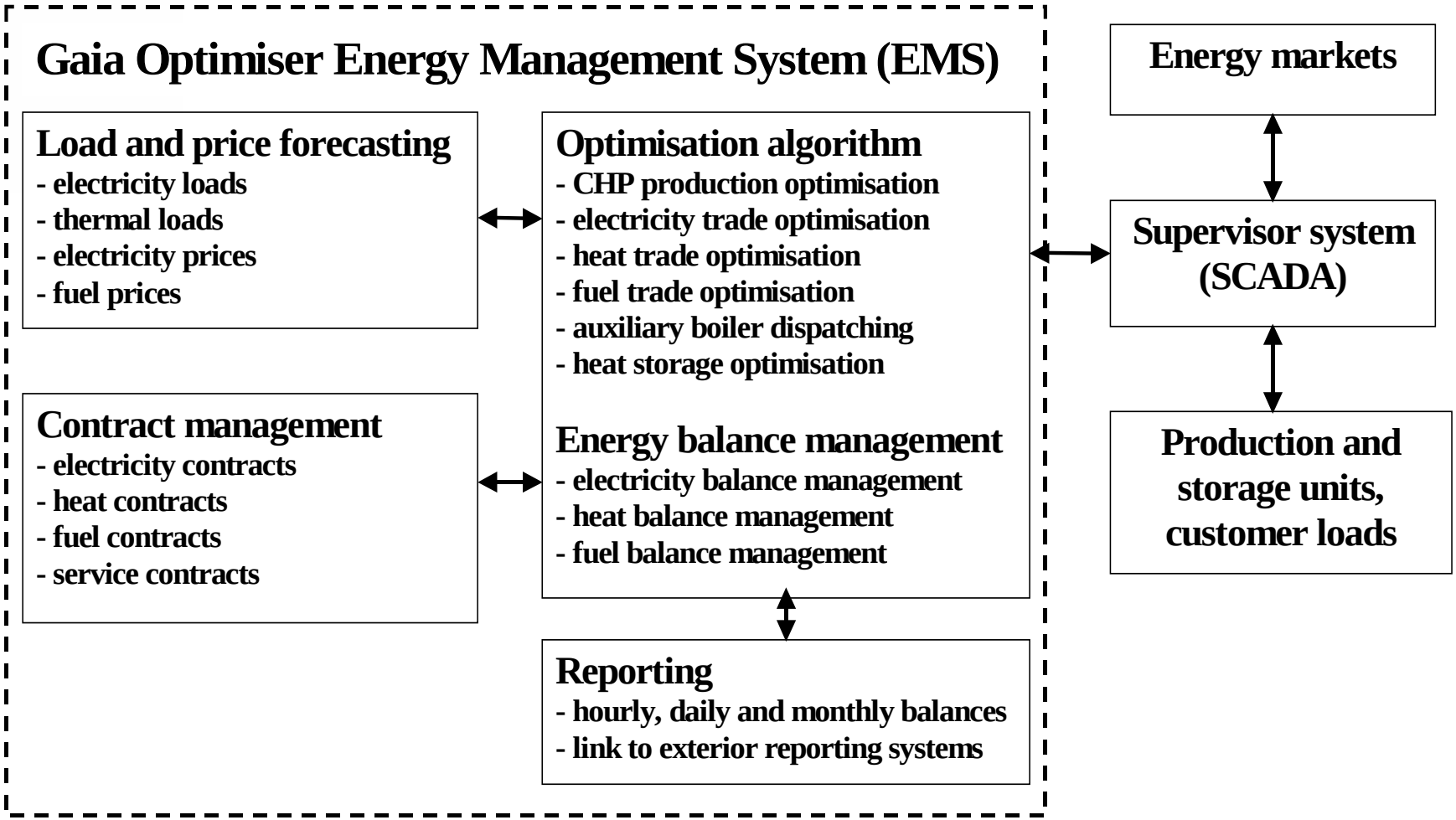
Source: Virtual FC Power Plant, FP5-project

Gaia Optimiser EMS

Energy management system for a service provider



Gaia Optimiser EMS structure



Real-time Optimisation

Real-time predictive and adaptive control scheme takes into account the load pattern, transmission tariffs, fuel and electricity prices and other variables, and controls the plant in the most efficient way.

Grid

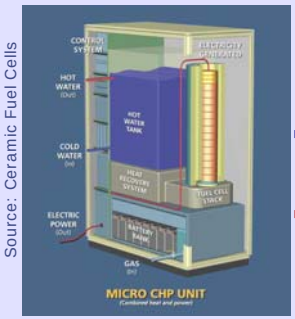
Auxiliary electricity

Surplus electricity

Gas pipeline

Fuel

Source: Ceramic Fuel Cells



CHP plant

Electricity

Heat

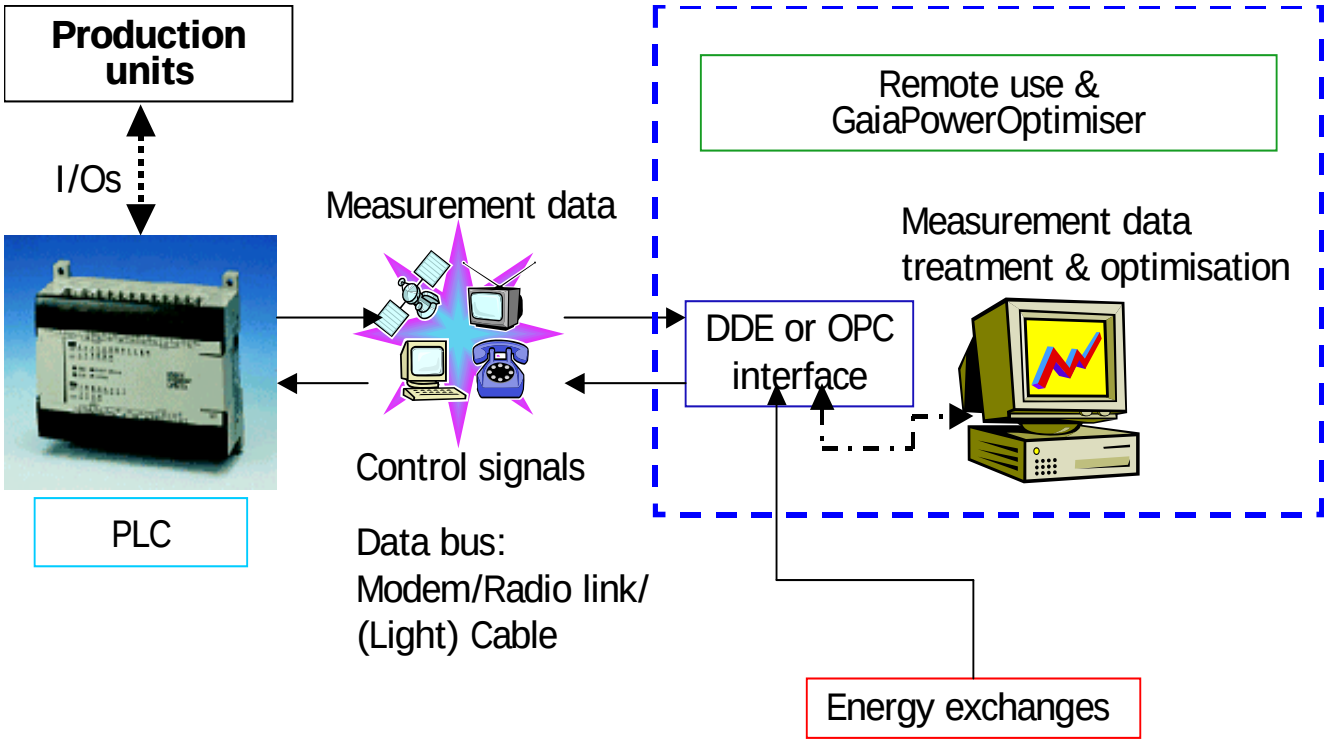
Consumer

Auxiliary heat

Gas boiler

Flexible Communication

Gaia Optimiser communicates with production units and energy exchanges with standard interfaces. Measurement data can be transferred via modem, radio link or cable.



Main Characteristics

Predictive control system

Adaptive timeseries model for electrical and heat load forecasting

Follow-up of the performance of power units

Real-time energy price follow-up (markets)

Optimisation and control of one or several power plants

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Optimisation Parameters

Characteristics of the CHP plant

Power and heat demands of the customer

Market prices of electricity and CHP fuels

Transmission and customer tariffs

Electricity and fuel taxes

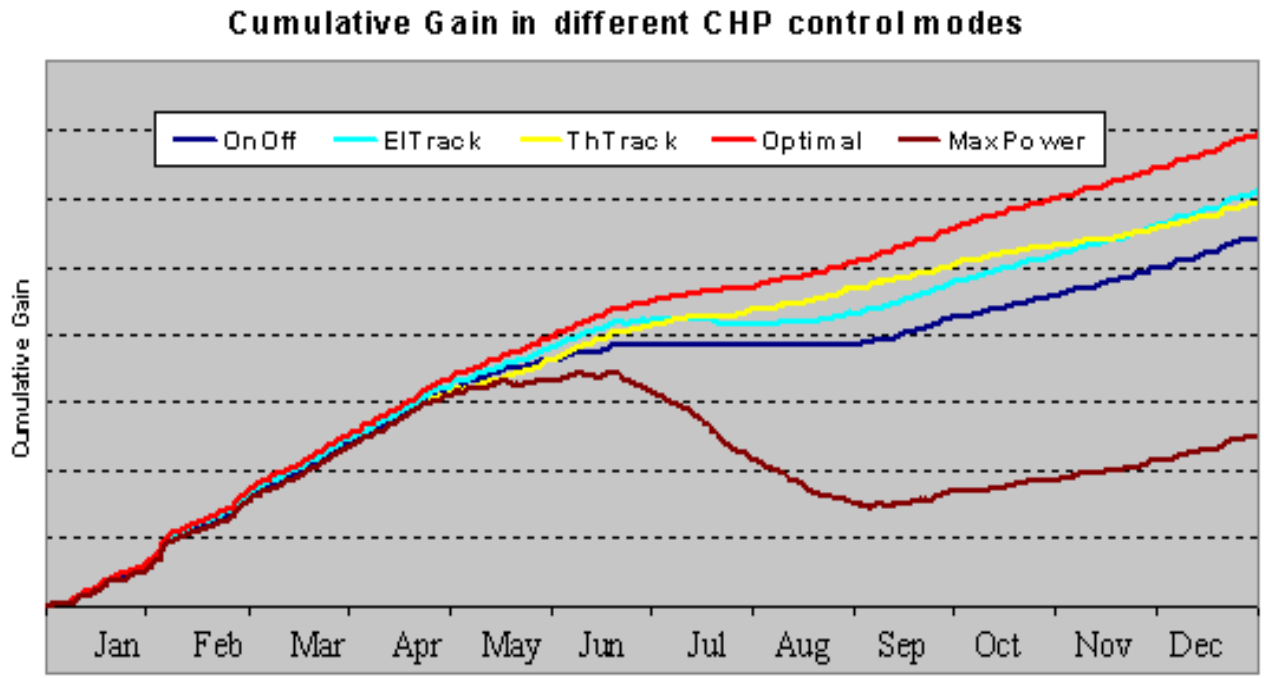
Maintenance costs

Etc.

Optimal Operation

There are several ways to operate the CHP units.

With Gaia Optimiser you can maximise the economic gain (see the red line).



Main Benefits and Advantages

- Adapts to short- and long-term changes in energy demand and prices
- Ability to forecast electricity and heat demand
- Real-time cost optimisation leads to optimal operation of the CHP plants
- Minimises the payback time of the CHP plant investment
- Can be integrated to existing supervisor and control systems

Gaia Power in the Dutch market

Gaia Power Oy has co-operation with ICT Embedded B.V. in the Dutch market

Gaia Optimiser software is planned to be used with:

- MicroCHPs at households
- CHP units at greenhouses

Possible future application could also be a system of several fuel cells controlled and optimised by Gaia Optimiser EMS (Energy Management System)