Decentralized Energy - Flexibility, stability and security
Power Generation Trend

**Yesterday**
Central power station

- Transmission Network
- Distribution Network
- House
- Factory
- Commercial building

In the current paradigm, the power is delivered through a passive distribution infrastructure to consumers. With the emergence of DG in a liberalised energy market, a new model is emerging.

**Tomorrow**
distributed/on-site generation with fully integrated network management

- Photovoltaics power plant
- Storage
- Flow control
- Local CHP plant
- Power quality device
- Wind power plant
- House with domestic CHP

In this model, a significant proportion of power generation is DG with distributed storage. Power can even flow from DG into the distribution network and from distribution to transmission networks.

Source: European Commission, New Era for Electricity in Europe
DG – Distributed Generation
“Onsite generation or close to point of consumption”

- Primary energy saving
- Emission (CO2) reduction
- Capital cost reduction
- Electricity retail cost reduction
- Reliability/security generation
- Transmission losses reduction

*source: annual report, 2008
www.dede.go.th
Based on generation year 2006, in next 20 year (2026):

- DG shares increase from 2% (1,759 MWe) to 17% (12,282 MWe)
- savings on primary energy 84.3 TWh/year (11%)
- CO2 emissions reduction 21 Mton (16%)
- capital cost saving US$1.42 billion (3%)
- and a reduction of required additional installed capacity of 4,955 MW (6%)

*Substantial potential of 3,200 MWe for natural gas based cogeneration (CHP)
- 1000 CHP in commercial buildings 500 MWe
- 880 CHP in industry with 2700 MWe

Project on Policy Research for the Promotion of R&D in Renewable Energy and Energy Efficiency in Thailand, Task: Natural Gas Based Cogeneration
DG POSSIBILITIES

1) Onsite Generation: CHP, RE
2) Island Mode
3) DG Helping System Stability
1. ONSITE GENERATION: CHP, RE
CHP Enablers

- Economic and financial
  - Three products from the same plant
  - Improved primary energy utilization
  - Possibility to utilize CHP electricity tariffs
- Acts by authorities
  - EU CHP Directive, >75% total efficiency
  - Kyoto protocol and emission regulations
  - CO₂ trading
- For the owner
  - Profitable operation
    - Income from electricity generation
    - Income from heat generation
    - Income from chilled water generation
  - Availability and reliability
Wärtsilä CHP

Fuel consumption 100%
- Electricity 43.4%
  - From the engines
- High temperature heat 26.6%
  - From the engines
- Low temperature heat 16.3%
  - From the engines
- Losses 13.7%

Power (net) 41.4%

Heat to DH system 42.9%

Plant auxiliaries 2%

Total efficiency 84.3%
Wartsila CHP – steam and hot water

Cogeneration

CHP plant for power, steam and hot water for industrial self generation

Performance: W20V34SG
Power output: 8730 kWe
El terminal efficiency: 44.3%
Steam 9 bar sat: 5.4 ton/h
Hot water 90/50 C: 4500 kWth
Total efficiency: 83%
Wartsila CHP – Flexible Application

1. Hot Water Driven Chiller
   - Cooling and heating

![Diagram of a Hot Water Driven Chiller system showing heat recovery for cooling and heating purposes.](image)
Wartsila CHP – Flexible Application

2. Hot Water Driven Chiller and Compressor Chiller - Cooling
3. Direct Exhaust Gas Driven Chiller
- Cooling
4. Direct Exhaust Gas Hot Water Driven Chiller - Cooling
5. Combined Cycle with Hot Water Driven Chiller - Cooling

Steam generation system

Exhaust gas -380 °C

Boiler
5 x 7 MW = 35 MWth

1-stage absorption chiller

44 MWth
12,500 TR
COP ~0.8

Power consumption 15.5 MWₑ

79.1 MWth
22,500 TR
COP ~5

~4.5 MWₑ

Steam turbine

105°C
1.2 bar(n)

Dump condenser

Electricity

Chilled water or district cooling
123.1 MWth
35,000 TR

13.4 °C

Cooling tower

212 MWth
Evaporation 340 m³/h
Bleed-off depending on water treatment

5 x Wärtsilä 18V46
Gross: 5 x 16.5 MW = 82.5 MWₑ
Net: 56 MWₑ
Wartsila Engines Performance

Otto engine performance @ 50 Hz ISO 3046

<table>
<thead>
<tr>
<th>Engine type</th>
<th>Power $kW_e$</th>
<th>El. eff. %</th>
<th>Heat DH 95/55$^\circ$C $kW_{th}$</th>
<th>Tot. eff. %</th>
<th>Chilled water 12/7$^\circ$C $kW_{ch}$ / TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>9L34SG</td>
<td>3 888</td>
<td>45,7</td>
<td>3 260</td>
<td>84</td>
<td>2 030 / 577</td>
</tr>
<tr>
<td>16V34SG</td>
<td>6 970</td>
<td>46,4</td>
<td>5 800</td>
<td>85</td>
<td>3 290 / 935</td>
</tr>
<tr>
<td>20V34SG</td>
<td>8 730</td>
<td>46,5</td>
<td>7 380</td>
<td>86</td>
<td>4 713 / 1 340</td>
</tr>
<tr>
<td>18V32DF on gas</td>
<td>6 080</td>
<td>44,6</td>
<td>5 500</td>
<td>85</td>
<td>3 720 / 1 058</td>
</tr>
<tr>
<td>18V50DF on gas</td>
<td>16 621</td>
<td>47,3</td>
<td>14 300</td>
<td>87</td>
<td>9 300 / 2 644</td>
</tr>
</tbody>
</table>

Data is given at 100% load at an ambient temperature of 25$^\circ$C and methane number of 80, p.f.=0.8.


Single stage hot water driven chiller (COP = 0.73)

1 TR = 3,517 kW
Some Examples in EU

Barajas Airport, Madrid Spain

Engines: 6 x Wärtsilä 18V32DF
Total electrical power: 33 600 kW<sub>e</sub>
Total heating output: 24 000 kW<sub>th</sub>
Total absorption chilling output:
18 000 kW<sub>ch</sub> / 5100 TR
Total efficiency 74%
Linate Airport, Milan Italy

Engines: 3 x Wärtsilä 20V34SG

Total electrical power: \( 24000 \text{ kW}_e \)

Total heating output: \( 17505 \text{ kW}_{th} \)

Total efficiency: 80.2%

Chilling is made at the passenger terminal across the air field
Academisch Medisch Centrum (AMC), the Netherlands

Engines: 3 x Wärtsilä 12V32DF

Total electrical power: 12 273 kW\textsubscript{e}

Total heating output: 12 000 kW\textsubscript{th}

Total absorption chilling output: 2 600 kW\textsubscript{ch} / 740 TR
Airports and airport terminals
Hospitals and medical institutions
Large office and business centres, hotel complexes and exhibition centres
Shopping centres
Food and beverage industry
Chemical and process industry
Electronic and computer industry
Universities, including campus areas and research laboratories
Data centres
Palm Oil Power Plant

combined cycle

111 MWe, Italy

Engines: 6 x Wärtsilä 18V46 + Steam turbine
Output: 100 MWe (engines) + 11 MWe (turbine)
Fuel: Liquid biofuel (mainly palm oil)
Emission control: SCR NOx abatement
UNIGRÀ, CONSELICE, ITALY

Engines: 3 x Wärtsilä 18V46 + combined cycle
Output: 50 MW (engines) + 6 MW (steam turbine)
Fuel: Liquid biofuel (vegetable oil)
Emission control: SCR NOX abatement
Delivered: September 2008

mainly palm oil
Merksplas, Belgium

GREENPOWER, MERKSPI AS, RFI GIIM
Engine: .................................................. 1 x Wärtsilä 20V32
Output: ........................................... 3 MWel + 7.5 MWth (Hot water)
Fuel: .................................................. Liquid biofuel (Jatropha oil)
Emission control: ................................. SCR NOx abatement
Delivered: ........................................... 03 2009

The heat produced by the plant is supplied to a drying facility for digested biomass recovered from a manure fermentation plant as well as a greenhouse producing tomatoes.

The 9 MW Wärtsilä 20V32 engine will provide electrical power sufficient to serve approximately 20,000 households. The gross electrical efficiency is 44.2% and an overall efficiency of more than 85%, annual CO reduction will be more than 36,000 tons.
Wärtsilä Fuel Versatility


- Diesel Oil (LFO)
- Heavy Fuel Oil (HFO)
- Crude Oil (CRO)
- Natural Gas (NG)
- Liquid Biofuels (LBF)
- Emulsified Fuels
- High Viscosity HFO
2. ISLAND MODE
Remote areas without “electricity grid” / “natural gas pipeline” such as:
- Oil & Gas Industry (on/off shore)
- Remote Islands i.e. in the south of Thailand
- Mining sites
ISLAND MODE

POWER PLANT CONCEPTS

- FIELD
- CUBE
- BARGE
### ISLAND MODE

**Name:** Mobile Bay  
**Type:** Power Generation for O&G Industry, Gas Power Plant, CHP  
**Location:** Alabama, USA  
**Owner:** Mobile Bay Energy  
**Delivered:** 1999  
**Engines:** 10 x Wärtsilä 18V28SG  
**Total electrical output:** 41.0 MW  
**Total thermal output:** 22.0 MW

The Mobile Bay CHP plant is the sole source of power and thermal energy for the liquid natural gas processing facility built on the same site by affiliates of the Mobile Bay partners. The processing facility operates 24 hours a day, all year round, in island mode.
Serving their mine, and will dispatch whenever the hourly price of market is favorable to export.
# ISLAND MODE

### OCCIDENTAL EDEN YUTURI, ECUADOR

<table>
<thead>
<tr>
<th><strong>MAIN DATA:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name:</strong></td>
<td>Occidental Eden Yuturi</td>
</tr>
<tr>
<td><strong>Type:</strong></td>
<td>Power Generation for O&amp;G Industry, Gas Power Plant</td>
</tr>
<tr>
<td><strong>Location:</strong></td>
<td>Ecuador</td>
</tr>
<tr>
<td><strong>Owner:</strong></td>
<td>Occidental Petroleum Inc.</td>
</tr>
<tr>
<td><strong>Delivered:</strong></td>
<td>Phase 1: 2002, Phase 2: 2005</td>
</tr>
<tr>
<td><strong>Engines:</strong></td>
<td>4 x Wärtsilä 18V32LN, 3 x Wärtsilä 18V34SG</td>
</tr>
<tr>
<td><strong>Total electrical output:</strong></td>
<td>40 MW</td>
</tr>
</tbody>
</table>

A 40 MW baseload power plant has been delivered to the Eden-Yuturi oil field development site in Eastern Ecuador. The plant is owned and operated by Occidental Petroleum Inc. and located on Block 15 in the Ecuador Oriente jungle at the Napo River.
the Caribbean island of Jamaica
• 49.5 MW power barge
• 74 MW power barge
3. DG HELPING SYSTEM STABILITY

DG POSSIBILITIES
What to do when the SUN does not shine?

**DG HELPING SYSTEM STABILITY**

![Graph showing solar irradiation over the year in three European cities: London, Madrid, Helsinki.](image1)

**SOLAR ENERGY**

**Fig. 4 - Typical variations in solar irradiation in three European cities during the year.**

![Graph showing solar irradiation over a typical day in Madrid.](image2)

**Fig. 5 - Solar irradiation during a typical day in summer and winter in Madrid.**
“What to do when the WIND does not blow?”

Fig. 2 - Typical output during a year for a windmill at an average site (red) and at an excellent site (blue).
The Plains End power plant is used to balance Colorado’s 1000 MW wind power capacity.

**PLAINS END GENERATING FACILITY, COLORADO, USA**

Type: .......................... Grid stability
Engines: 20 x Wärtsilä 18V34SG
+ 14 x Wärtsilä 20V34SG
Total output: .......................... 227 MW
Fuel: ................................. Natural gas
Delivered: .......................... 2002 and 2008
DG HELPING SYSTEM STABILITY

A WÄRTSILÄ POWER PLANT

- Remote controlled operation
- Fast starting and stopping
- Fast loading:
  - 100 sec to 25% load on gas, 15 sec on oil from start order
  - 3 min to full load in oil mode
  - 6 min to full load in gas mode
- Wide load range, 30–100%
- 44% net electrical efficiency at full load on oil, 46% on gas
- Flat part-load efficiency curve
- Grid black-start without external power

GOODMAN ENERGY CENTER, KANSAS, USA
Type: Grid stability
Engines: 9 x Wärtsilä 20V34SG
Total output: 76 MW
Fuel: Natural gas
Delivered: 2007
DG HELPING SYSTEM STABILITY

KEEP COUNTRY INDEPENDENT OF FOREIGN ENERGY AND BEING COUNTRY’S OWN Reserve

“Where people can’t even watch television in the evenings, stable energy supply is very important issue”

AZER ENERJI, SANGACHAL, AZERBAIJAN
Type: ........................................Baseload
Engines: .......... 18 x Wärtsilä 18V50DF
Total output: ..................... 300 MW
Fuel: ................................. Natural gas
Delivered: ............................. 2008