Application of **Green Hydrogen Turbine Combined Cycle Tri-generation Plant** with **Micro Turbines** Organic Rankine Cycle (ORC) **Waste Heat Adsorption Chiller** for **High Rise Buildings**

The urgent need to reduce carbon intensity in high rise building

Local Energy Mix

- CLP Electricity PV Panel, Coal, Nuclear, Landfill gas, Fossil Gas & oil.
- HKE Electricity PV Panel, Wind Turbine, Coal, Fossil Gas & oil.
- Towngas Landfill gas, Fossil with mix of natural gas and naphtha, 50% grey hydrogen content.
- High power consumption in high rise building, efficiency increase helps but cannot achieve net zero carbon.
 - Air-conditioning need
 - Computing power and lighting
 - Lift, escalator and water pumps
 - Hot water, steam



The Challenges for Continues Back-up Power

- To provide long back up power for advance office tower requires:
 - Huge volume of diesel for only 6 hours back up
 - Large number of MW grade diesel gensets and UPS
- The risk to rely on diesel genset only.
 - No diesel refilling service in critical event.
 - Road bloakage.
- Other design and operation problems
 - Huge diesel tank would make DG approval difficult
 - Seriously affect data centre building land usage and flexibility.
 - The need to empty diesel tank due to short diesel shelf life





Recent Events of Long Power Outage

- Major Long Power Outage
 - Taiwan due to planning issues
 - New Orleans due to hurricane
 - Texas due to snow storm
 - Puerto Rico due to hurricane
 - Auckland, New Zealand due to grid problem
- The trend for more Long Power Outage due to
 - Electrification of
 - Cooking
 - Air-conditioning and Heating
 - High power electrical vehicle charging
 - Shut down of fossil power plants
 - More less stable renewable power
 - More extreme weather





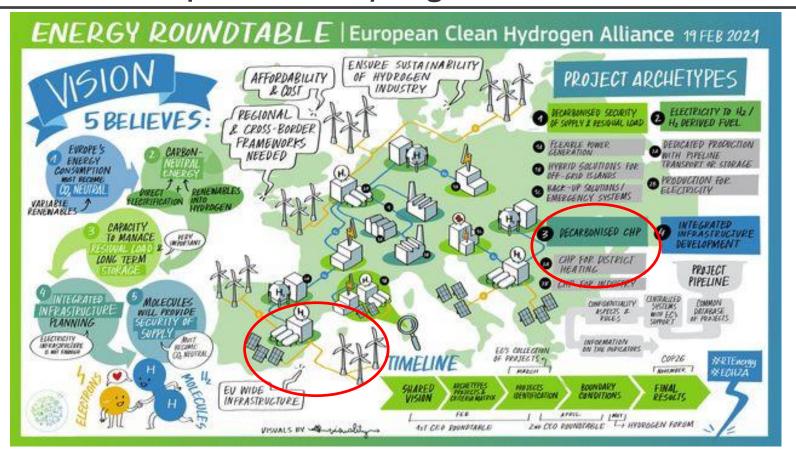


Why Green/Blue Hydrogen

- Advantage of Hydrogen as Green Energy Storage
 - High energy density
 - High energy storage capacity
 - · Hydrogen could be generated from water using renewable electricity and
 - Using patent process from biogas & natural gas that also produce solid carbon for easy carbon sequestration.
- Easy to reuse to generate electricity, heat and propulsion power.
 - Hydrogen fuel cell to power light and heavy vehicles.
 - Hydrogen turbine for power, heat and aviation.
- Approach zero emission
 - Generate water vapour
- Hong Kong town gas network could be used to transport green/blue H2.
 - 50% of hydrogen already being transport via gas network today
 - Could increase green hydrogen and renewable content in local gas network.
 - Negative Carbon is technically possible.



Vision of European Clean Hydrogen Alliance



Concept of Hydrogen Tri-generation

- Our system will recover hydrogen onsite:
 - Using HRS system
 - To power micro turbine ORC combine cycle to generate electricity
 - To recovery most waste heat to generate hot and chilled water for air-conditioning.
 - Use any slip CO2 in flue gas to feed small green house on roof top
 - Thermal efficiency over 85% (41% higher than local fossil power plants)
 - Close to 96% of hydrogen utilization.
- A 1200kWe system will reduce:
 - 5248ton of CO2 emission per year
- Provided that:
 - 8000 hours of annual operation
 - Hydrogen in gas network is Green/Blue or
 - Gas with renewable certification
 - Waste heat is recovered and utilized

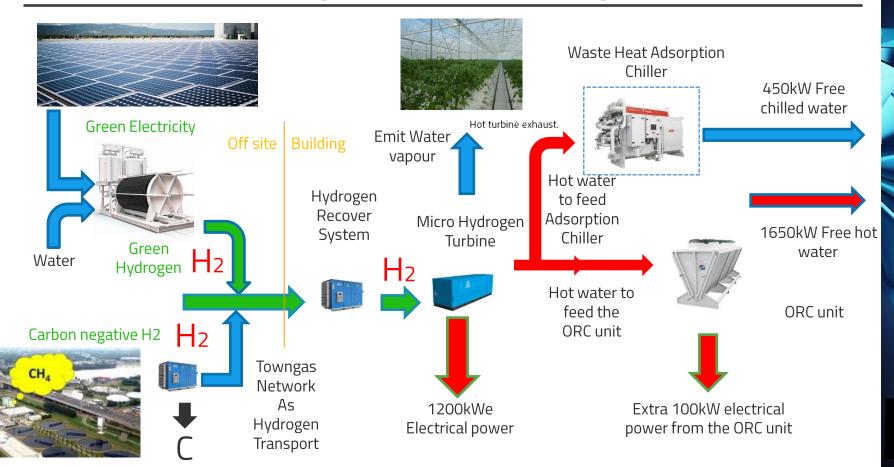




Our Solution

- Green/Carbon negative hydrogen could be generate <u>off-site</u> by:
 - PV panel, wind turbine, nuclear power > electrolyser > H2
 - High temperature process using sewage/landfill/natural gas to generate H2 and solid carbon (biochar)
- Local gas network to transport Green/Blue Hydrogen.
 - Slight increase hydrogen content in gas network to 52%
- High percentage Hydrogen to be recovered <u>on-site</u>:
 - Hydrogen recover system HRS
 - To power micro turbine combine cycle to generate electricity
 - Recovery all waste heat to generate free chilled and hot water
 - Use any slip CO2 in flue gas to feed small green house on roof top
 - Close to 96% of hydrogen utilization
 - Turbine could operate during power outrage as well as to provide base load

Indirect Green Hydrogen Turbine ORC Tri-generation Plant



Micro Turbine Combined Cycle with Organic Rankine Cycle (ORC)

BENEFITS

High efficiency

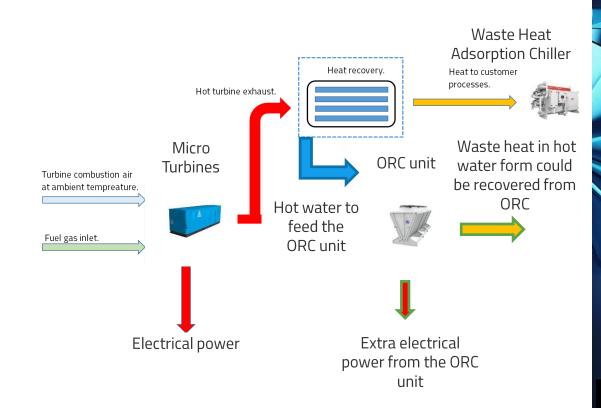
- ➤ Approach 40-44% electrical
- > Maintain 41% @ half load
- ➤ Thermal efficiency > 85% CHP and CCHP

Advantage over fuel cell

- > 60-100% hydrogen as fuel
- > High gas quality flexibility
- > No contamination risk
- ➤ Much longer life
- > Low initial & maintenance cost

Significant reduction in environmental impact with

- > Emit mainly water vapour
- ➤ No oil related pollution



Combines high system efficiency, wide operation windows, low emission & low maintenance

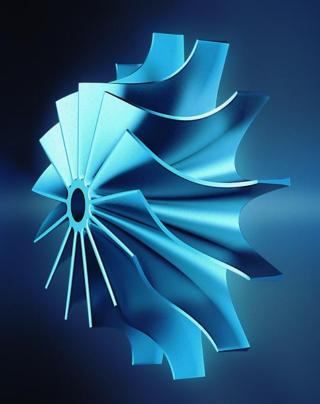
Hydrogen Recovery System (HRS)

Functions

- Gas compression
- Membrane system to filter out hydrogen
- Optional PSA system
- Return of methane to gas header
- Pressure control system for supply to turbines
- Pressure reduction system for gas return

Micro Turbines

The most efficient small gas turbines in the world that could operate with Hydrogen



Utilized the most efficient small gas turbine

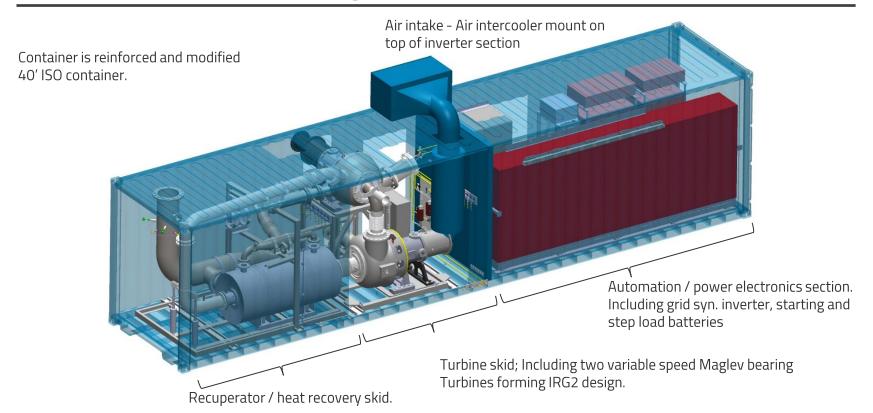


Highlights

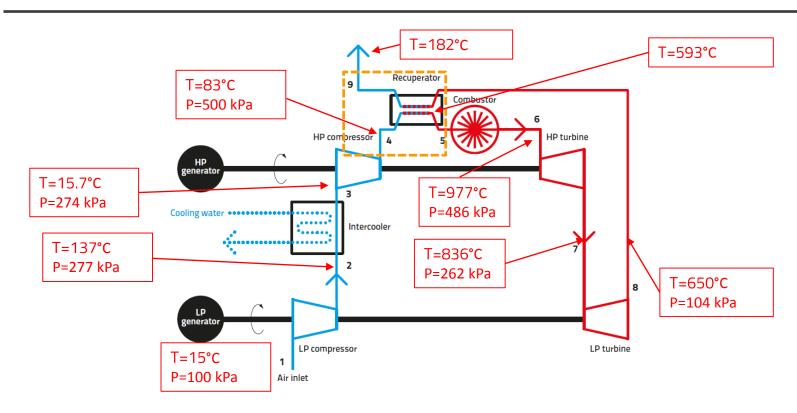
- Design for industrial operation
- Heavier build, slower rotation speed
- IRG2 Design with 2 turbines, intercooler and recuperator
- Magnetic floating bearings
- Advance burner with hydrogen capabilities

400 kWe module
40 % electrical efficiency*
>42-44% Turbine + ORC

40' ISO container package



Schematic of IRG2 turbine



Equipment operation at nominal output and standard operating conditions.

The Hydrogen Burner





- Developed in German
- Homogenies temperature distribution
- Low risk of flashback due to high jet velocity

Key advantages of Micro Turbine vs Gas Engine

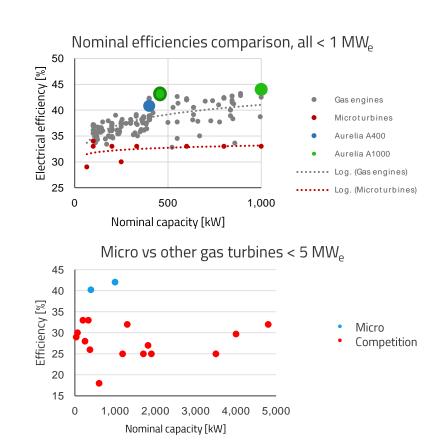
Electrical efficiency is the major factor that influences the fuel cost for power generation.

Low maintenance to further enhance profitability

No-oil bearing system (AMB) means no friction, no oil change and no wastage.

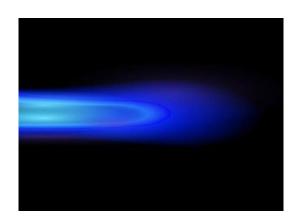
Turbines benefit from features like fuel flexibility and cogeneration possibilities, now it also match engines in efficiency with super low NOx emission.

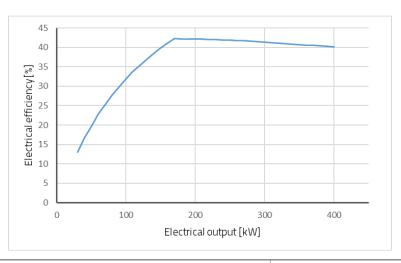
It is the *first small turbine that designed to* outperform gas engine in all areas and to match fuel cell in a low cost; practical package.



Turbine Performance

Electrical efficiency >40.2 % Efficiency with ORC Up to 44% Half load efficiency 41% Electrical output to grid 100-440* kW_e Output voltage 400/480 V Output frequency 50/60 Hz Maximum output current (400VAC) 597 A Electrical connection 3 phases, 4 wires





NO _x emissions at 15 % O ₂	<20 mg/Nm ³
Exhaust gas flow at full power	2.2 kg/s
Exhaust gas temperature at full power	185°C
Exhaust energy at full power	1 188 MJ/h
Heat recovery from intercooler	278 kW
Heat recovery from exhaust gas	240 kW
Exhaust gas O ₂ level	17.5 %

Micro Turbine vs Gas Engine – Emission



Micro Turbine

NO _x emissions at 15 % O ₂	<20-30 mg/m ³
Exhaust gas flow at full power	2.2 kg/s
Exhaust gas temperature at full power	185°C
Exhaust energy at full power	1 188 MJ/h
Heat recovery from intercooler	27.8 %
Heat recovery from exhaust gas	24.0 %
Exhaust gas O ₂ level	15 %

Highlights

- Very low NOx emission due to
 - Continues flame
 - Low flame temperature (TIT @900°C)
- High O₂ level at exhaust suitable to match with post fire boiler

Gas Engine

NO _x emissions at 5 % O ₂	250-500 mg/m ³
Exhaust gas flow at full power	_
Exhaust gas temperature at full power	360-450°C
Exhaust energy at full power	-
Heat recovery from jacket water	20 %
Heat recovery from exhaust gas	24 %
Exhaust gas O ₂ level	5 %

Highlights

 Due to explosive nature in the combustion chamber results in very high temperature and high NOx emission.

Organic Rankine Cycle (ORC) Waste Heat Power Generator



- R245fa as heat transfer medium
- Proven with multiple job references in Asia and Europe
- Generate up to 40 kWe of electricity with 400-500kW of waste heat from Micro A400 Turbine
- Single stages heat input using up to 120 deg C Hot water generate from turbine waste heat for ease of connection.
- Heat recovery for CCHP with dry cooler
- Higher power versions are available

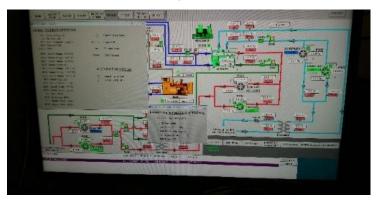
Waste Heat Power Adsorption Chiller

- Water as refrigerant
 - Non-toxic, non-flammable, nonozone depletion, no heavy metal.
- Proven with multiple local job references.
- Generate up to 450-600kW of free chilled water from the waste heat of the 1200kWe turbines
- Single stages hot water input at 88 deg C
- Non-crystalize solid adsorber material is used.



SCADA Control System

User Interface PC



- Provide un-man operation based on timer schedule
- Connect major components by high level interface
- Data collection functions with trend log and report generation capability

Benefits

Base on available data of One Taikoo Place:

- Base on GFA of 100,000sqm
- Current annual renewable power of 135,500 kWh
- Assume annual power demand of 6,775,000 kWh
- Generate 6,737,500kWh of zero carbon power
 - System of 1300kW H2 turbine electricity and 450kW of free cooling
- Maintain 7,000 annual operation hours
- Reduce EUI by 67.38kWh/sqm/year
- Building EUI will be = 0.38kWh/sqm/year



Thank you!