CONVION

FUEL CELL SYSTEMS

FUTURE OF DISTRIBUTED POWER GENERATION

Polttokennot: käyttökohteet nyt ja tulevaisuudessa

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Different fuel cell technologies are suited for different fuels and applications

FC Type	Anode Fuel	Cathode Fuel	Operating temp (°C)	Efficiency (LHV)	Application
PEM	H_2	Air	60 – 100	30 – 40	Portable Small residential Transportation
AFC	H_2	O_2	60 – 120	30 – 40	Portable Small residential Transportation
PAFC	H_2	Air	150 – 250	35 – 45 50 – 70 *	Med. Residential Commercial
MCFC	H_2, CO, NH_3, CH_4	Air+CO_2	550 – 700	45 – 55 80 – 90	Industrial Commercial Large residential
SOFC	H_2, CO, NH_3, CH_4	Air	650 – 850	45 – 55 80 – 90 *	Industrial Commercial Large residential

* Co-generation

SOFC : Solid Oxide Fuel Cell
SOC : Solid Oxide Cell
SOE : Solid Oxide Electrolysis

INTRODUCTION TO CONVION

CONVION

- Enables Power generation with SOC technology
- Leading SOFC systems in the 50kW+ power range
- Substantial IPR on SOFC system technologies
- Customer demonstrations ongoing
  - Italy and Finland

- History at Wärtsilä: R&D since 2001, Technology demonstration since 2004
- Established in 2012 as an independent company
- Key shareholders : VNT Management (VC), Employees and Wärtsilä Corporation

CORE PRODUCT C60 – MODULAR 60KW POWER UNIT

- Process design and analysis
- Product design and manufacturing
- Core component design and specification
- Power electronics and grid connection
- Adaptive systems control
- System related know-how and IPR

C60 THE NEW GENERATION

Simplicity

- Product design enable lower CAPEX
- Process solutions enable lower OPEX
- Easy to install
- No water consumption

Flexibility

- Fuel flexibility for biogas, natural gas and hydrogen
- Component and stack flexibility for improved competitiveness
- Modular design for flexible manufacturing

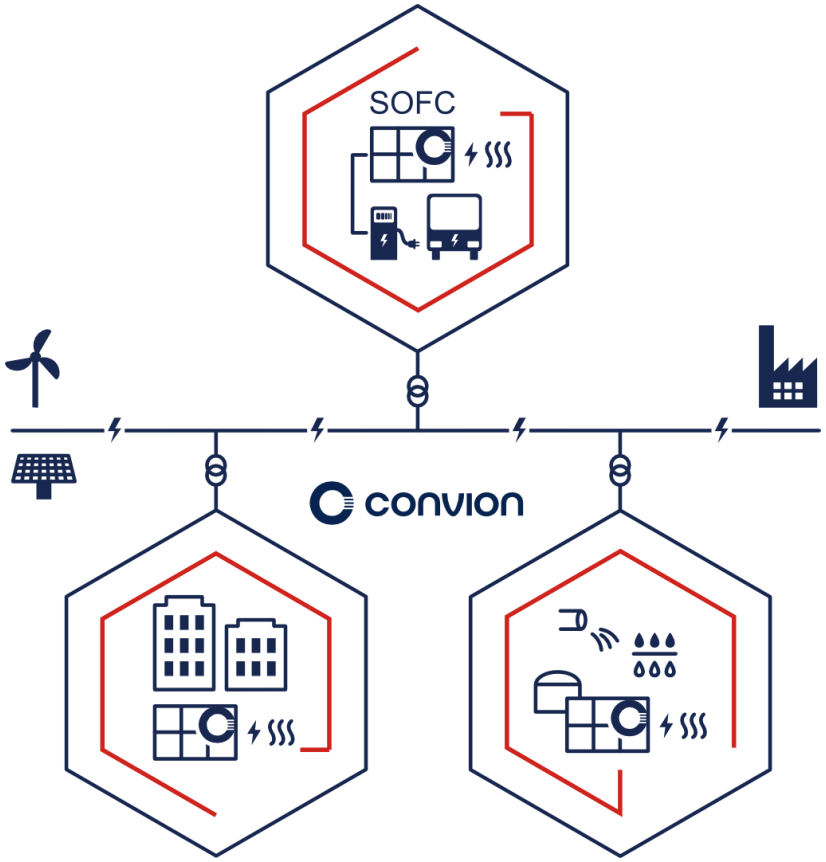
Performance

- Premium electrical efficiency 60% – 65%
- Built-in option for heat recovery
- Power security in island mode
- Low emissions

Electric output	**60**	**kW net-AC**
Electrical efficiency	60+	% (LHV)
Thermal output	27	kW (exhaust cooled to 40°C)
Total efficiency	84	% (LHV) (exhaust cooled to 40°C)
Range of electric output	65 - 33 kW (normal modulation range 100-50%, temporary modulation down to 30%)	
Water consumption	None	
Exhaust gas flow	200°C, 575 kg/h, dew point 37°C	
Fuel envelope, LHV	440-850kJ/mol biogas 55 % - 100 %-mol CH_4 with CO_2 as a diluent	

Distributed generation to enable renewable grid
Convion provides part of the solution for the energy challenge

Increasing need for flexibility and energy storage



Increasing need for on-site capacity

Increasing need for clean and secure power

Increasing need for Bio energy and Waste to energy

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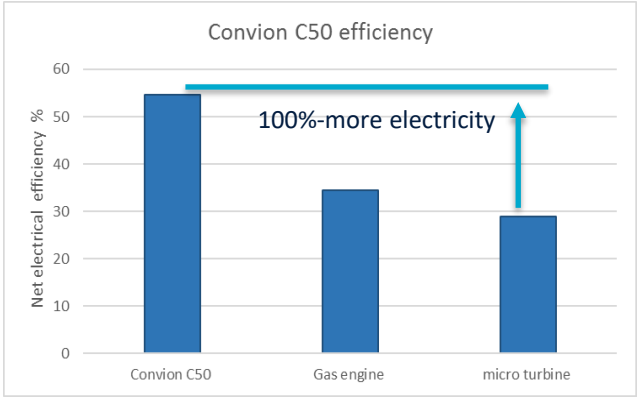
CUSTOMER BENEFITS

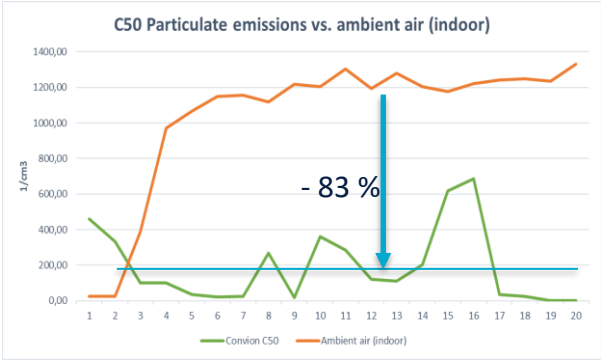
Premium efficiency

- 53 - 65% electrical efficiency
- Lower fuel cost
- Less GHG emissions



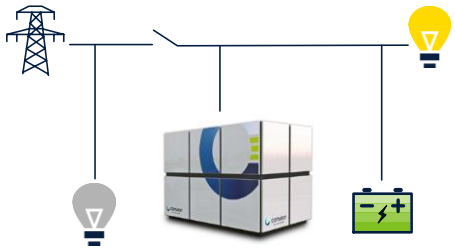
Clean power source

- 83 % less particulates than indoor air
- No SO_X and NO_X emissions
- 100 % renewable in biogas use



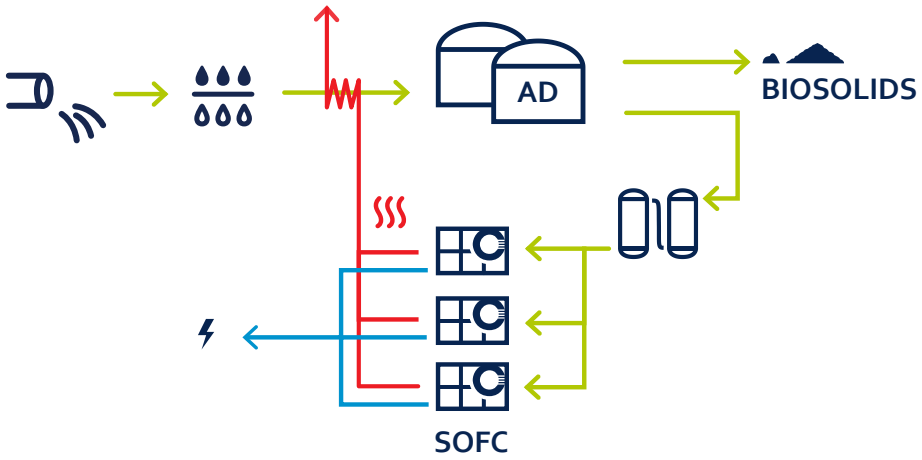
Power security

- Onsite, gridd independent power
- Island mode capability



Avoided cost

- Lower infrastructure cost
- Onsite power generation
- Cost and energy efficiency



- Biogas installation operational since 2017
- Electrical power of thee units 170kW
- Net electrical efficiency exceeding 50% (net_ac)
- A biogas fueled SOFC's covers 30% of electrical and 100% of thermal loads of a wastewater treatment facility in Turin, Italy.

FCH · POLITECNICO DI TORINO · CONVION · smat gruppo · VTT · Imperial College London

MARKET ENTRY, BIOGAS

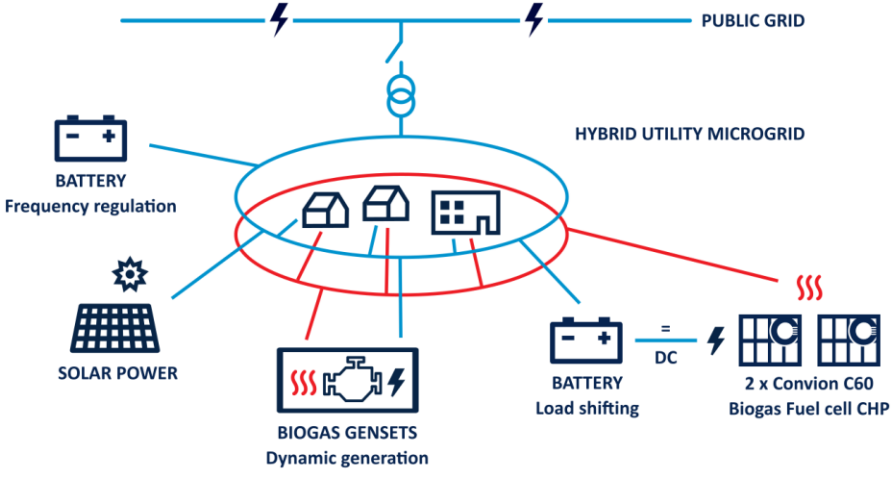
MARKET ENTRY, SMART GRID

CONVION AS PART OF POWER REVOLUTION

PARTNERS
LEMENE PROJECT

SIEMENS Ingenuity for life
MERUS POWER
Höyrytys Oy
convion
SOLARIGO
kiwatti
JL metals oy
FINTRAS
ELENIA
FINGRID

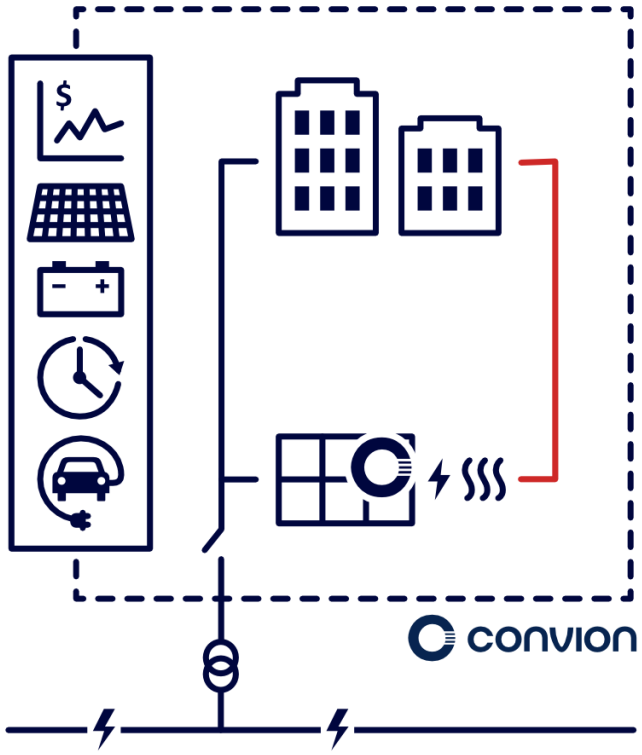
- LEMENE project demonstrate Convion fuel cells in Smart Grid application
- Two C60 units (120kW) combined with energy storage provide 1MW dynamic capacity
- The project arise interest also in Asia. Convion is cooperating with large power utility in China
- Fuel cells will improve sustainability and power security of the grid



Fuel cell technology elcogen
LEMPÄÄLÄN ENERGIA

Microgrid applications:

- Continuously operating, dependable and efficient generators are an enabling technology for microgrids
- Offices, hotels, hospitals, educational, sports and wellness facilities

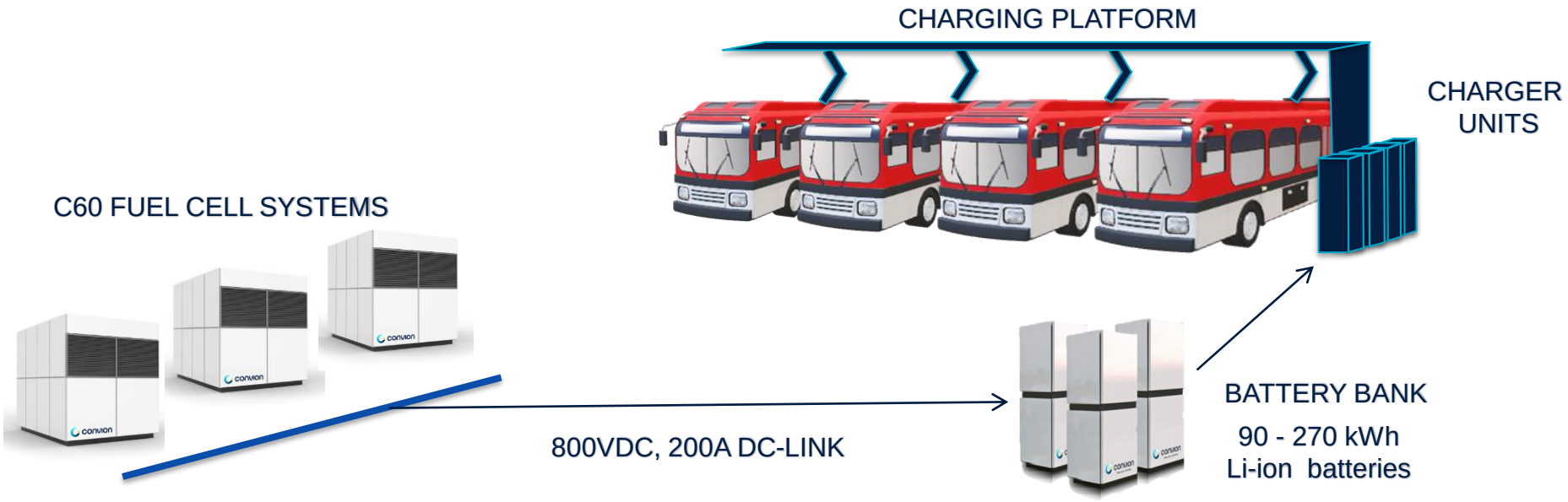


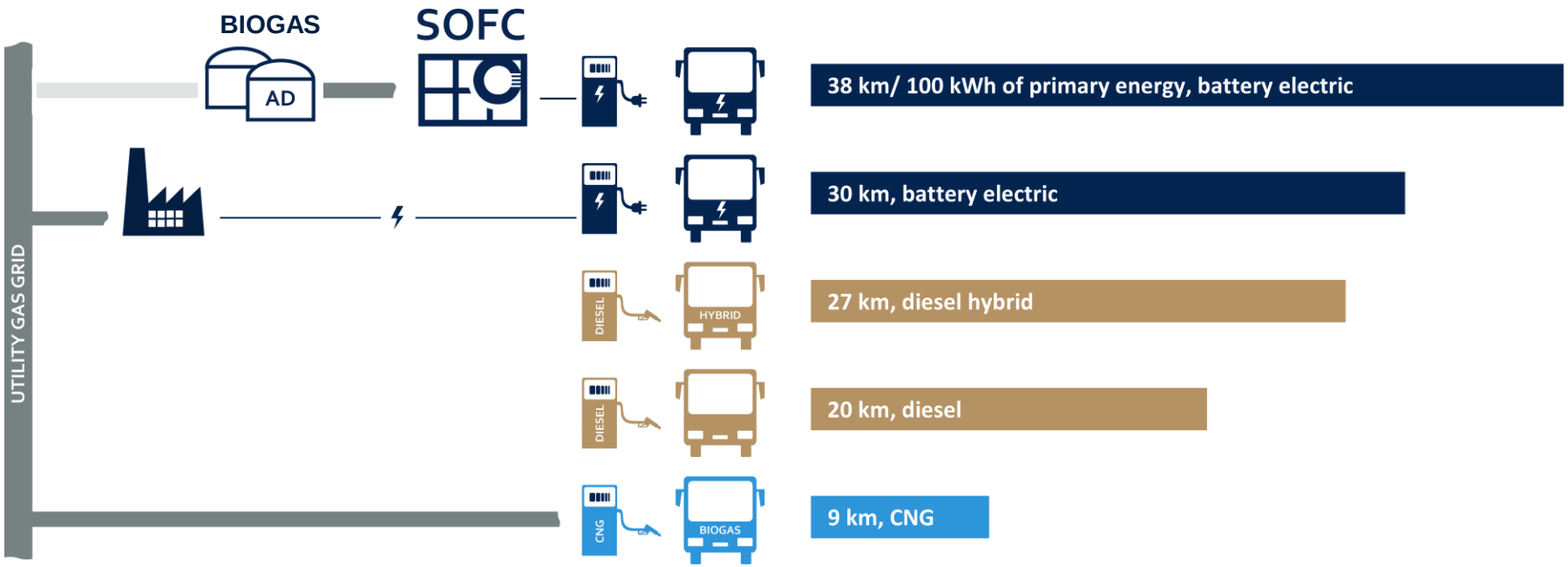
Multiple value aspects:

- Lowering of OPEX – energy & demand charges
- Power-to-heat ratio well matching with loads in buildings
- Improved resiliency
- No noise or local emissions of PM, NO_x, SO_x or HC

- Three Convion C60 fuel cell systems provides continuous capacity of 180kW
- C60 combined with batteries can provide grid support and excess capacity for peak loads
- C60 can be connected battery bank or charging station via DC-link

- Fuel cell with battery bank do provide needed capacity and dynamics
  - 3xC60 + 90kWh Li-ion battery can provide 460kW peak load for 15 min or 215kW for 2h
  - Can be discharged and charged within 4-8 hours





- Onsite power generation + EV charging
- Better energy efficiency without grid reinforcement
- No transmission losses, high availability, heat utilized locally
- Four times longer driving distance with bio gas

Source : HSL 2014, VTT, Convion,
https://www.hsl.fi/sites/default/files/uploads/ajoneuvo_ja_polttoainetekniikan_mahdolliset_autoliikenteen_paastojen_vahentamisessa.pdf

HYBRID MARINE SOLUTION WITH LNG

CONVION AS PART OF MARINE REVOLUTION

- Use of LNG will open marine market for fuel cells
- Hybrid systems: Main ICE engines + batteries + Fuel cells
- For better energy efficiency, power security and feasibility
- Convion fuel cells are enabler for improved sustainability
- Cooperation with industrial leaders provide unique opportunity for Convion

Source: RoyalCarribean International ; https://www.royalcaribbeanpresscenter.com/infographic

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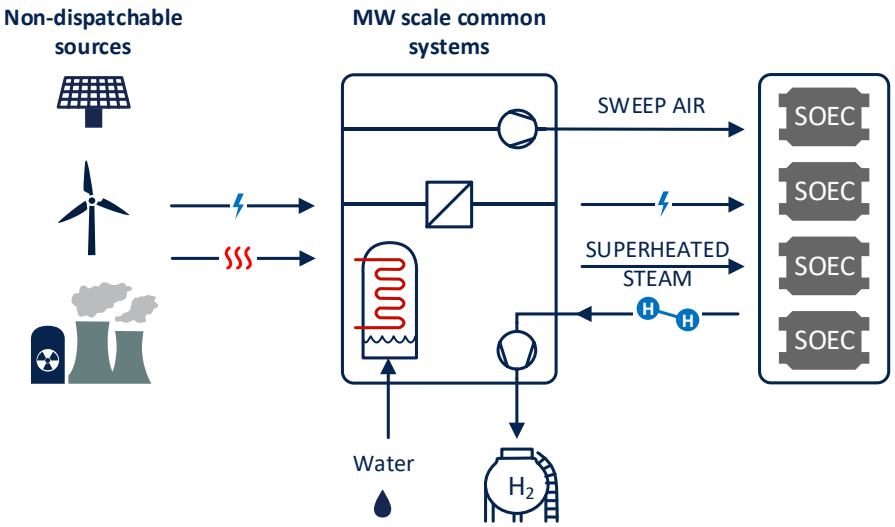
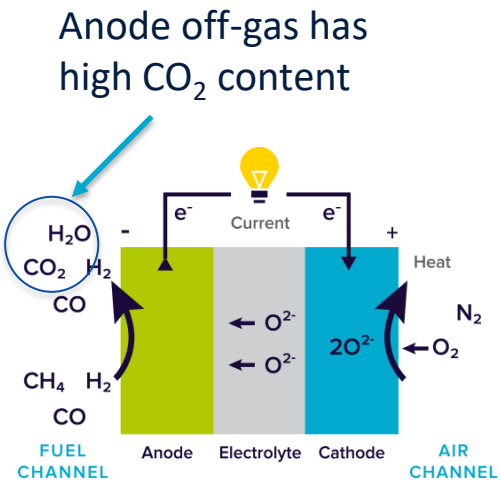
Convion offering for SOE value chain

- Convion capabilities are also applicable for H_2 production by SOE technology
- Convion know-how and technologies do provide core solutions for hydrogen production as part of a total ***Power to Gas*** or ***Power to X*** value chains
- 250kW SOEC module can be developed based on the current fuel cell products



SOFC enable CO_2 separation

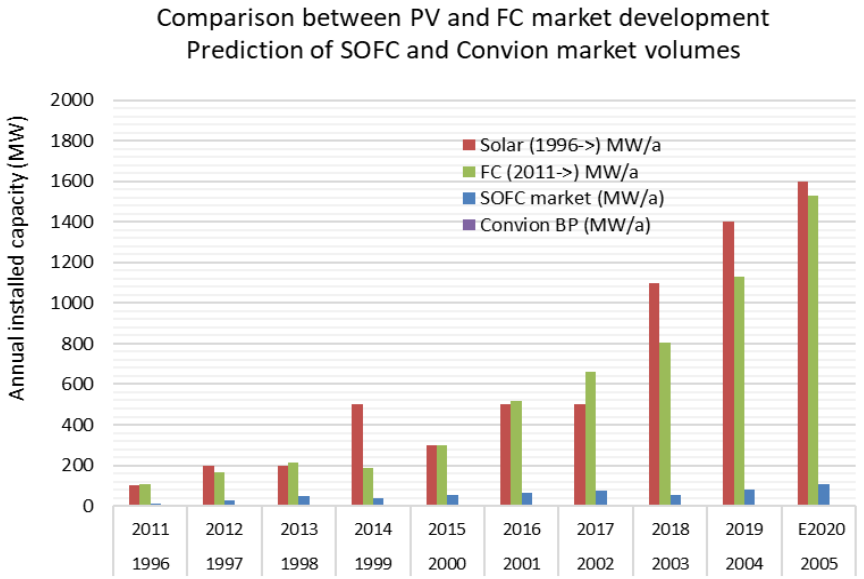
BIOGAS
NG / LNG

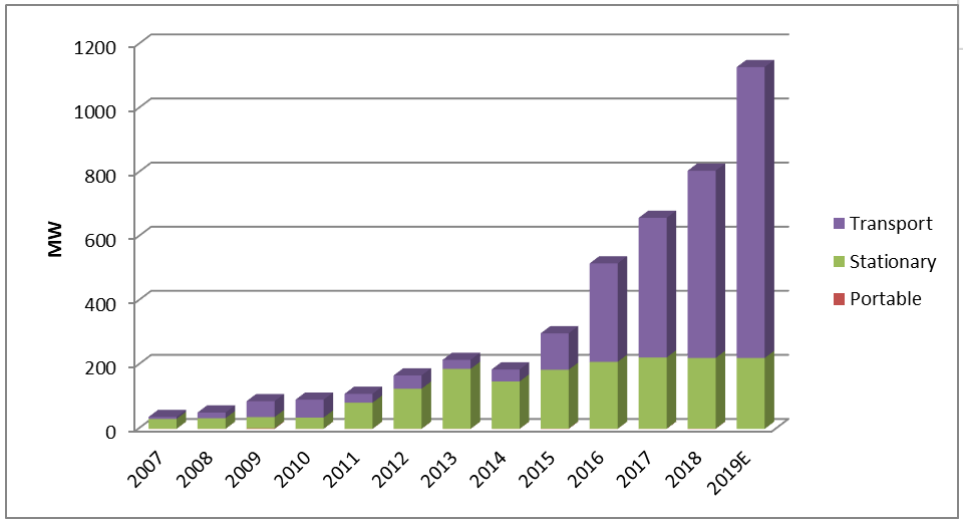


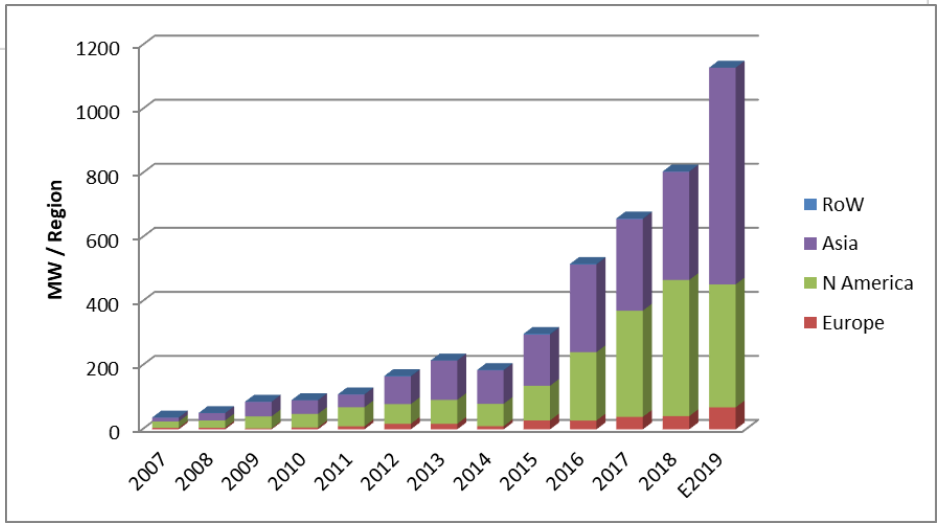
- Biogas operation for 100 % renewable power
- SOFC are suited for CO_2 separation
  - Enable CO_2 capture for greenhouses or gas industry
  - Enable negative CO_2 emission at small scale
    - With biogas reduction of CO_2 emissions is 520 kg/MWh

Global fuel cell market has continued to grow reaching total capacity of 1GW in 2019

- Growth has been mainly in Asia and focused to transport applications. Stationary applications has shifted from large MCFC towards smaller projects.
- SOFC applications correspond 78 MW volume (6,9%)
- The market development continue to follow PV market with 15y time difference with reasonable accuracy







Source: http://www.fuelcellindustryreview.com/
https://commons.wikimedia.org/wiki/File:World_Photovoltaics_Installed_Capacity.svg

H2 and Electrolysis market gaining increasing interest

For the 34 GW integrated renewable hydrogen plants in the EU, (3.4Mton). **The investment is about 67 billion Euro**.

For the 10 GW integrated renewable hydrogen plants in Ukraine (Mton). **Total investments 20 billion Euro**

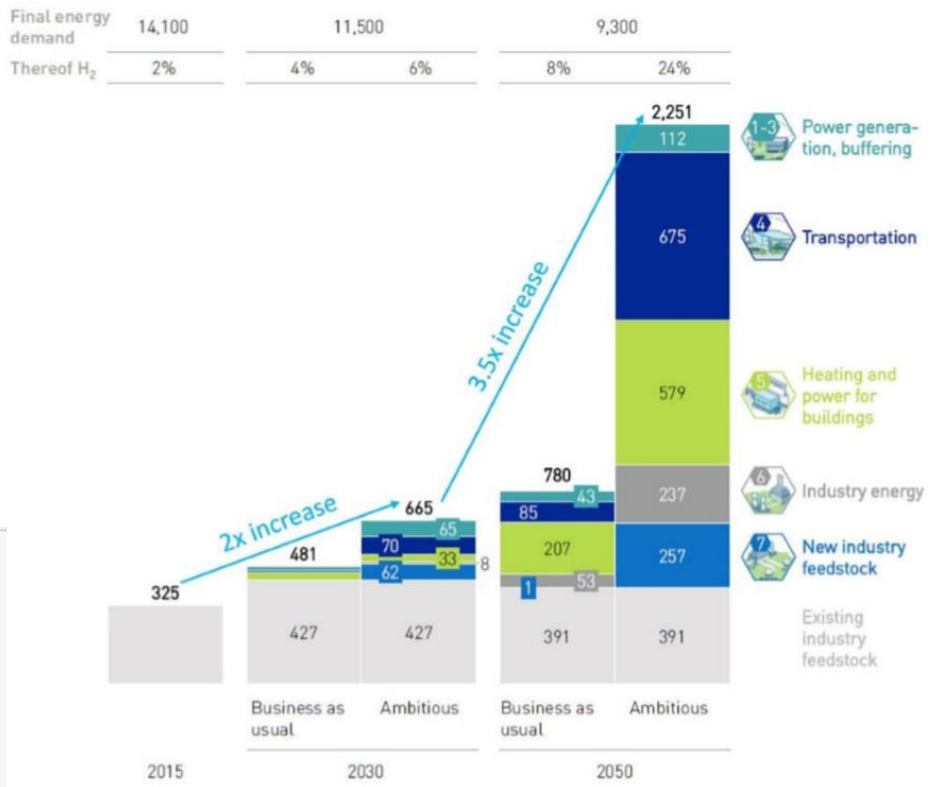
For the 10 GW integrated renewable hydrogen plants in the North Africa. **Total investments ~60 billion Euro**.

HYDROGEN 2030: THE BLUEPRINT

	GW Electrolyser	Mt H_2	Renewable + electrolyser Investment Billion Euro	Tender based investment subsidy	Additional support
Captive market EU	6	1,0	27,7	30%-40%	Compensation grid fees always
Hydrogen plant EU	34	3,4	67,3	40%-50%	Compensation high transport cost first years
Hydrogen plant Ukraine	10	1,0	20,1	40%-50%	Compensation high transport cost first years
Hydrogen plant North Africa	30	3,0	71,4	40%-50%	Compensation high transport cost first years
TOTAL	80	8,4	186,5	72-91 billion Euro	

Table 5: Investments and tender based capitalized investment subsidies in renewable energy and electrolyser capacity according 2x40 GW green hydrogen initiative

Figure 5. Hydrogen demand in 2050 in Europe, under various scenarios



Additional potential in Asia, Australia, etc.

Source: Hydrogen Europe

Conclusions

- Energy market must and will change
- Fuel cell technologies are an important enabler of energy disruption
- De carbonization will drive renewable H_2 as energy carrier in various fuels
- Fuel cell provides highest conversion efficiency both for *Gas to Power* and *Power to Gas*
- Same fuel cell works for both directions enabling massive production volumes and competitive cost

- Convion, Elcogen and VTT have leading technologies, but stronger value chains are need for capturing the global opportunity.

CONTACTS

Thank you

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