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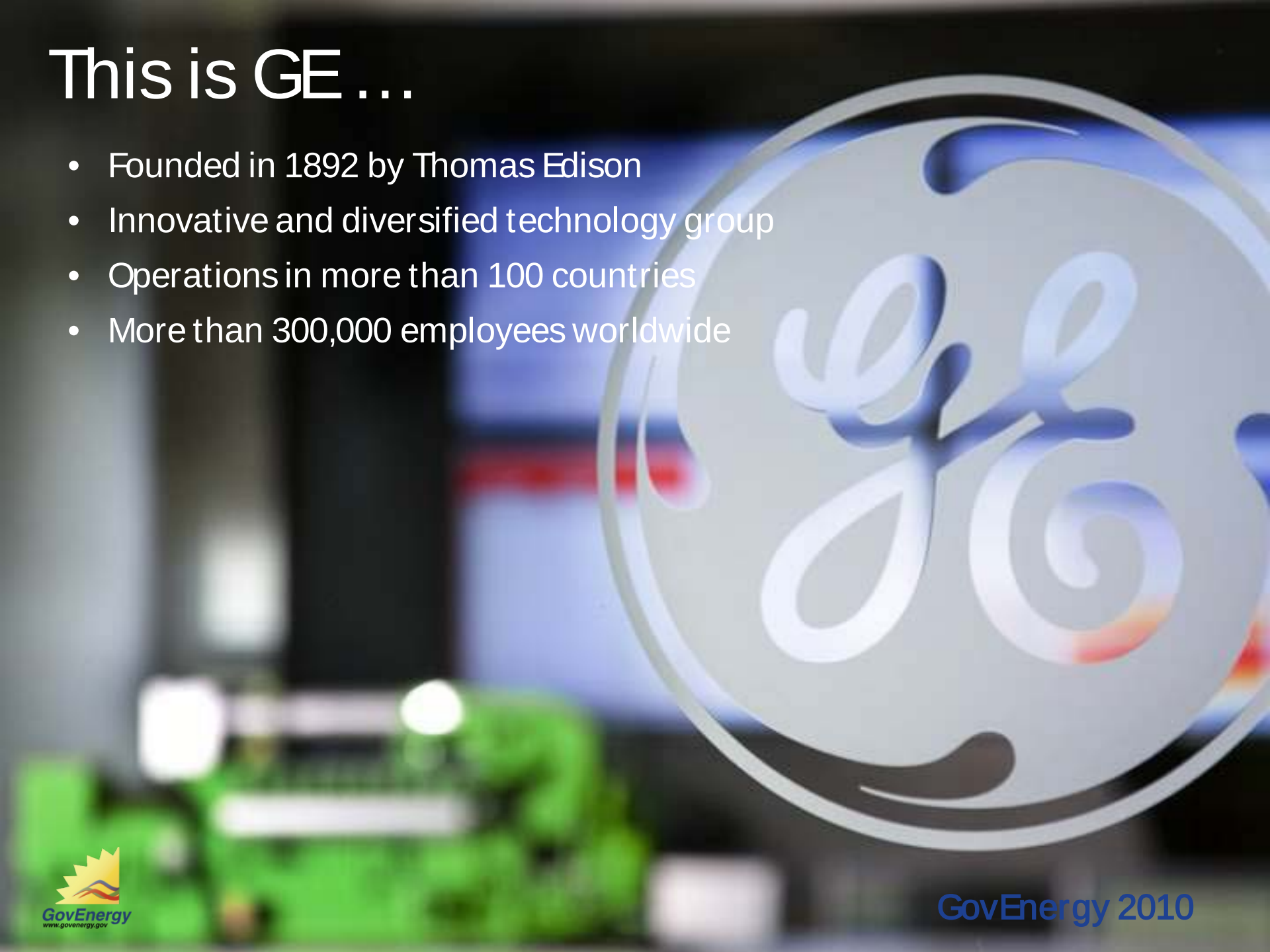
CHP Fuel Flexibility

This is GE …

- Founded in 1892 by Thomas Edison
- Innovative and diversified technology group
- Operations in more than 100 countries
- More than 300,000 employees worldwide



Alternative Fuels Defined

Alternative Fuels:

Fuels that can substitute traditional fuels...

Opportunity Fuels:

materials from agricultural or industrial processes that would otherwise be wasted but could power a CHP system and are available at or in close proximity to a CHP site. http://www.epa.gov/chp/definitions.html

Opportunity Fuel

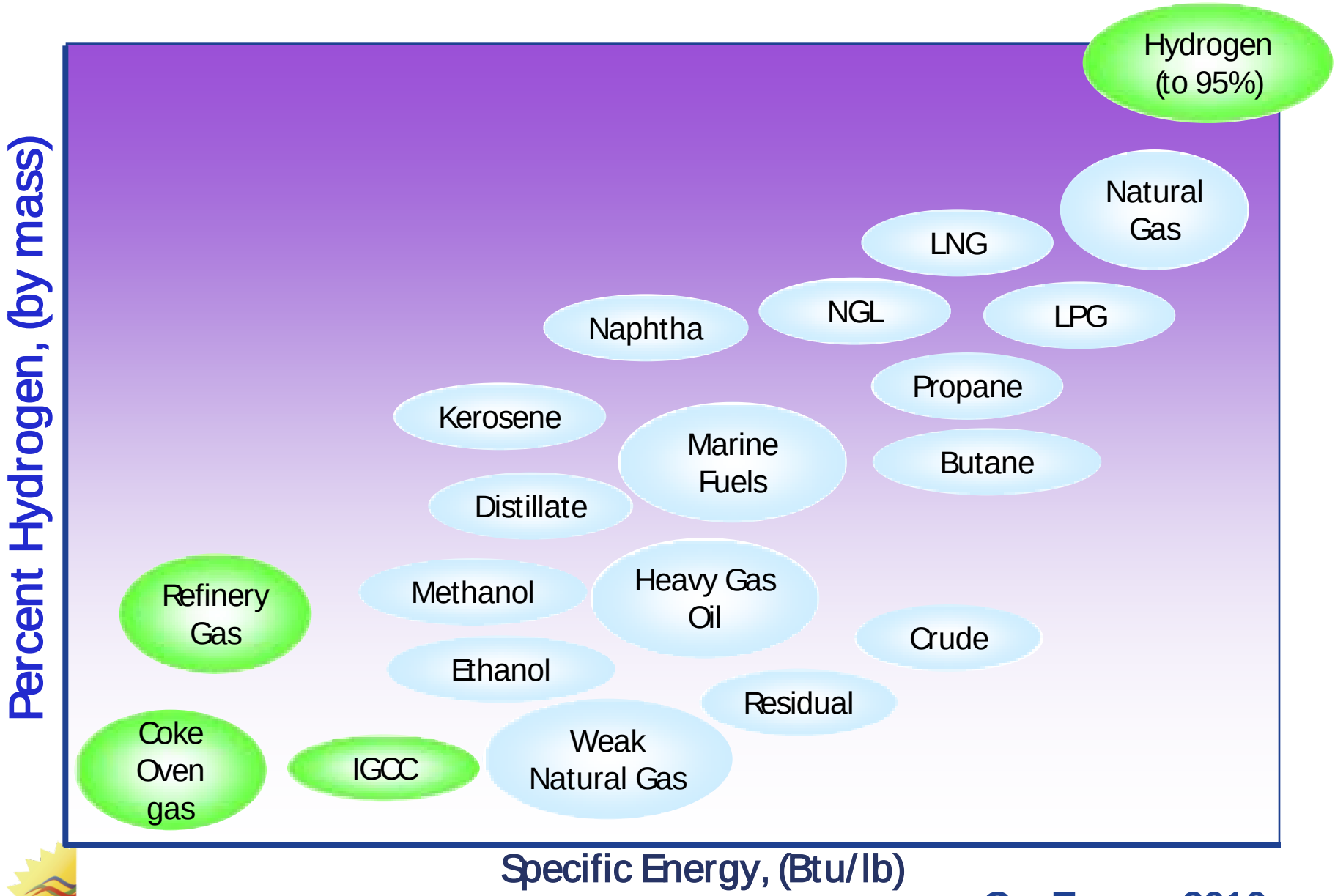
	Gasification Digestion	Gas Turbine	IC Engine	Boiler STG
Biomass Fuels				
Anaerobic Digester Gas			X	X
Biomass Gas	X		X	X
Biomass Liquids	X	X		X
Vegetable Oils				X
Black Liquor	X			X
Crop Residues	X			X
Ethanol				X
Food Processing Waste	X		X	X
Landfill Gas (LFG)		X	X	
Municipal Solid Waste	X	X	X	X
Sludge Waste	X			
Wood and Wood Waste	X		X	X
Industrial & Fossil Fuel Derived				
Blast Furnace Gas		X	X	X
Coke (Coal and Petroleum)	X	X	X	X
Coke Oven Gas		X	X	X
Industrial VOC's		X	X	X
Textile Waste	X		X	X
Coalbed Methane		X	X	X
Wellhead Gas		X	X	X
Tire Derived Fuel	X	X	X	X

Latest Developments: Gas Turbines

New Fuels that can be burned

- **Oils:** including crude and other refiner residuals, which are heated to acceptable levels to enable the needed viscosity for gas turbine combustion.
- **Process By-Products:** derived from the chemical, oil and gas, or steel sectors, many of these fuels cannot be transported or stored, and their essential appeal will be to reduce fuel supply in industrial plants in the carbon-constrained environment.
- **Low Calorific fuels:** derived directly from abundant fossil carbon (refinery residuals, coal, lignite, tar sands, and shale oil), they represent great potential for the carbon-constrained economy, provided they are subjected to carbon capture.
- **Renewable Liquids:** more evenly distributed around the world, they are of prime interest due to their overall neutral carbon balance. Vegetable oils ("VO") as virgin or recycled product, Alcohols, Esterified VO or Fatty Acid Alkyl Esters (FAAE)

Fuels Experience With Heavy Duty Gas Turbines



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New market dynamics

End-users seeking fuel diversification & flexibility…while maintaining availability

Industry Drivers:

- Diversified Power Generation mix (in terms of both fuel sources & suppliers)
- Greater energy independence/autonomy
- Efficient use of energy / Less emissions

Ultra/Low LHV	Medium LHV	Gaseous Fuels	High H2 Fuels	Liquid Fuels
Blast Furnace Gas	Weak natural gas	Natural gas	**Refinery gas**	Naphtha
BFG mixed	Landfill gas	**LNG**	Petrochemical gas	Distillates
Air blown IGCC	Coke oven gas	LPG	**Hydrogen power**	**Crude Oils**
Biomass gasification	**Corex gas**			**Residual Oils**
	IGCC Coal/Petcoke			**Bio-Fuels**

Expand Core Capabilities

Steel industry (China, India, E. Europe, USA ..) Reduce energy consumption & emissions

Increasing reliance on LNG …Variability - Periodic or frequent changes in fuel gas composition

Heavier crude oils (Driven by EOR) Growing interest for bio-diesels & ethanol

Refinery IGCC plants …Steep learning curves …Exceed 90% capacity factor

Valuing refinery & petrochemical gases CCS …Regulations, carbon constrained in EU & soon in USA

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Fuel flex …expanding the operating envelope

Customers seeking fuel diversification & flexibility

- Increasing fuel prices & volatility of supply driving the idea of substitution
- Cleaner & more flexible technology …greater environmental sensitivity, lower emissions, increased turndown, multi-fuel, durability

Gas fuels

- NG …LNG variability
- Other Gases …broader range (H2 to Low BTU)

Liquid fuels

- Light crudes …higher performance
- Heavier crudes …greater capability

Synthetic fuels

- Gasification …refinery residuals, Pet coke
- Steel mill & process off-gas
- Bio-fuels …gas or liquids

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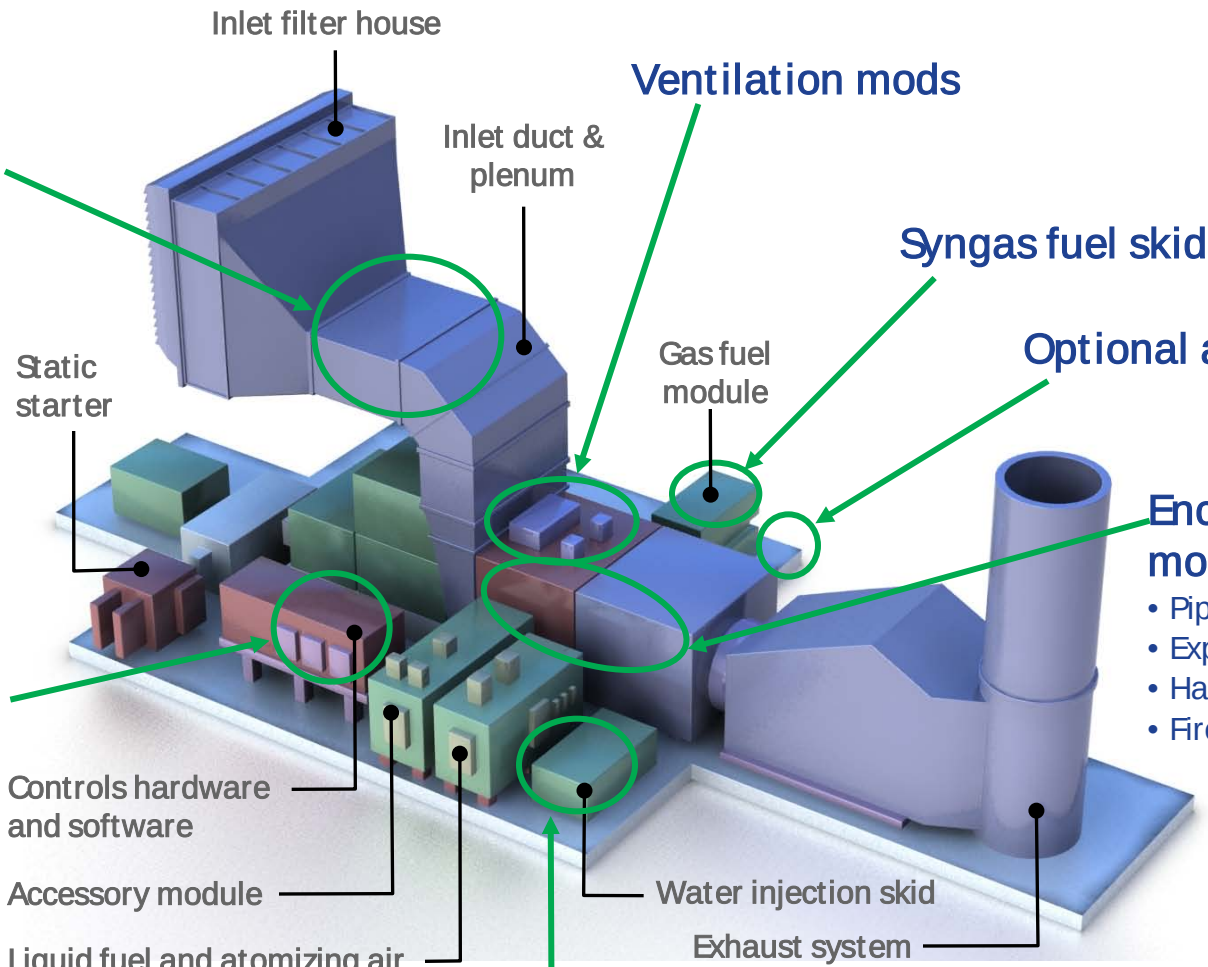
Syngas turbine controls & accessories



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Latest Developments: Internal Combustion Engines

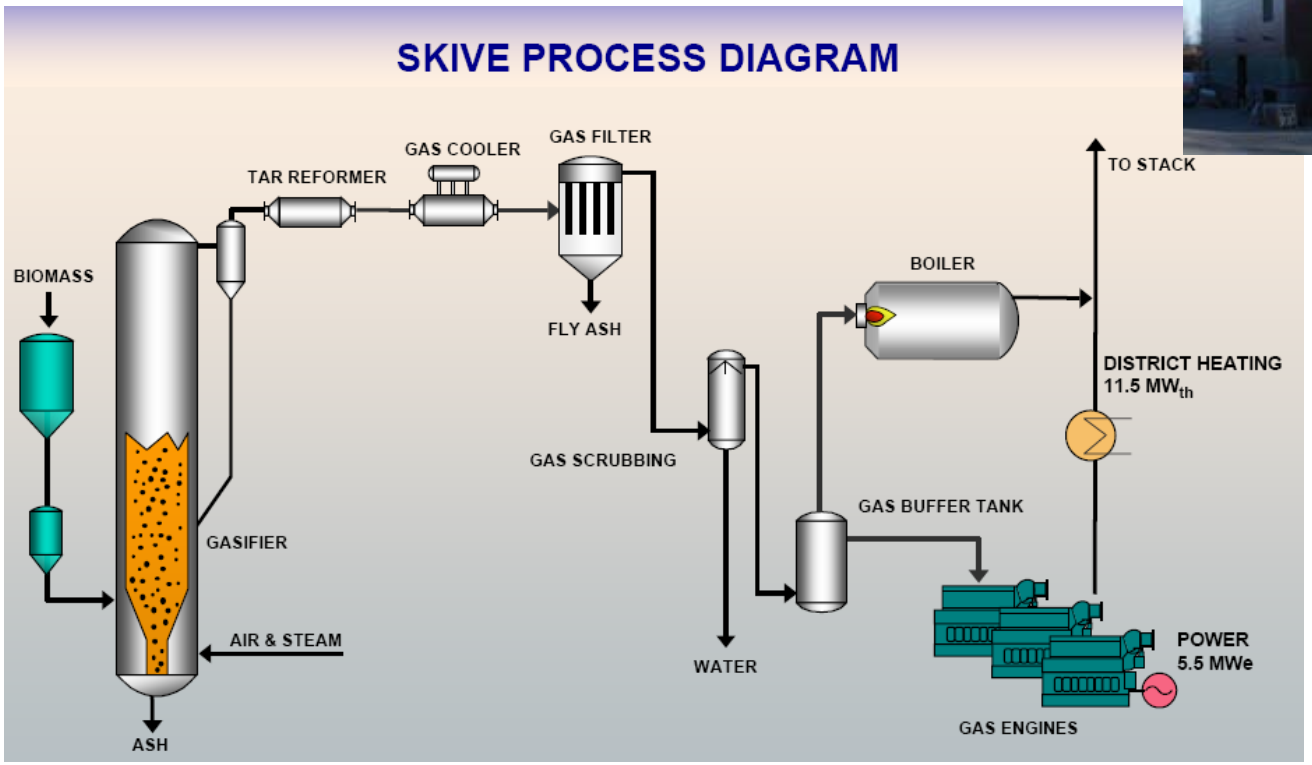
New Fuels that can be burned

- Wood Gas
- Biogas
- Sewage Gas
- Flare Gas

Next market and development work

- High Hydrogen

Woodgas Plant Skive/Denmark



Commissioning 07/2008

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Gas Properties

Heating Value

Calorific value and thermal value indicate the energy content of a gas. The former can be differentiated from the later only through the heat of vaporization of the water resulting from combustion, the water is in liquid form after it has already liberated its condensation heat.

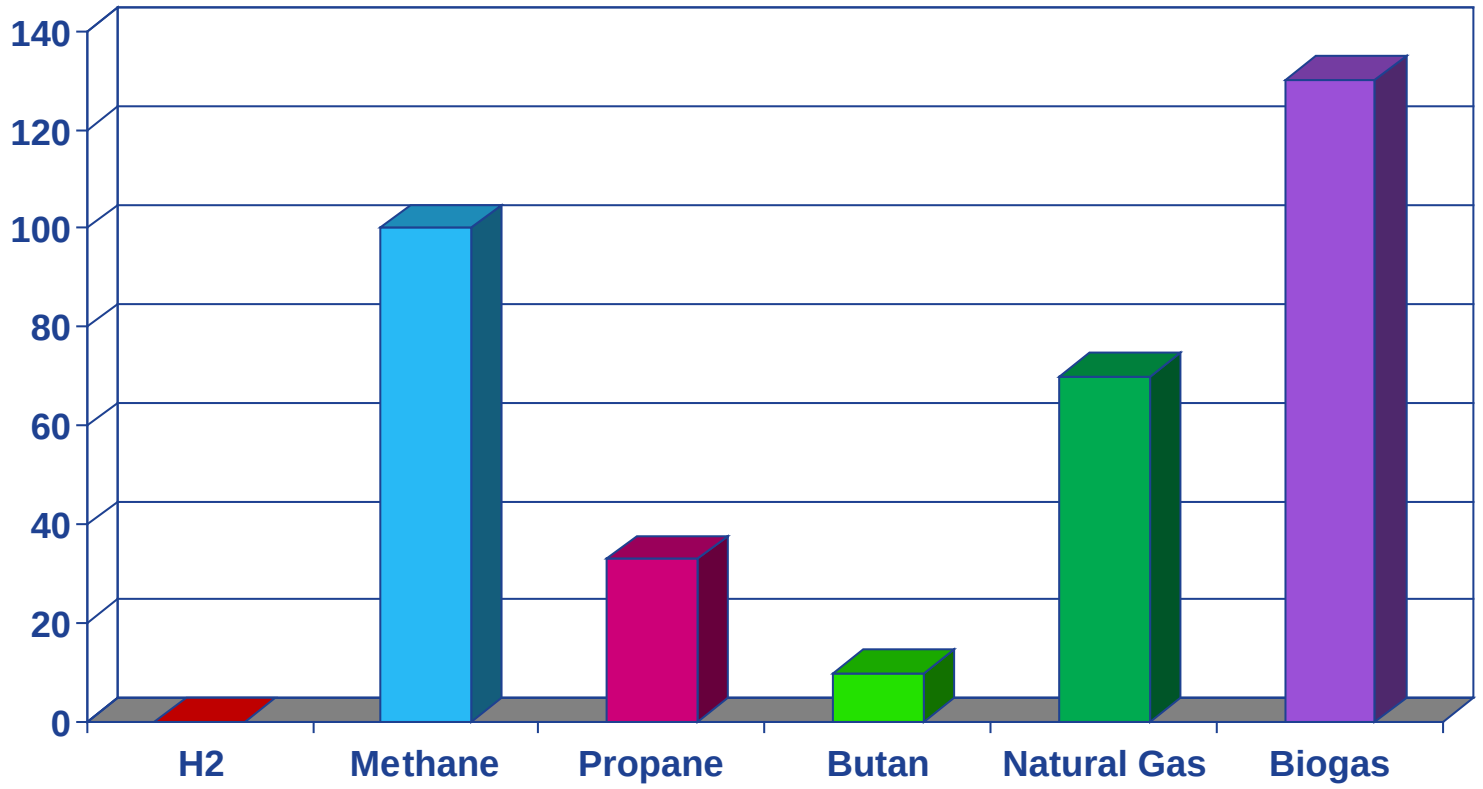
Methane Number

Determinant parameter for knocking resistance of a gas. It is comparable to the octane number of gasoline and indicates the percentage methane volume ratio of a methane-hydrogen mixture which, in a test engine and under controlled conditions, indicates the same knocking resistance as the gas to be tested.

Laminar Flame Speed

Laminar flame speed is the speed at which the oxidation takes place.

Methane Number



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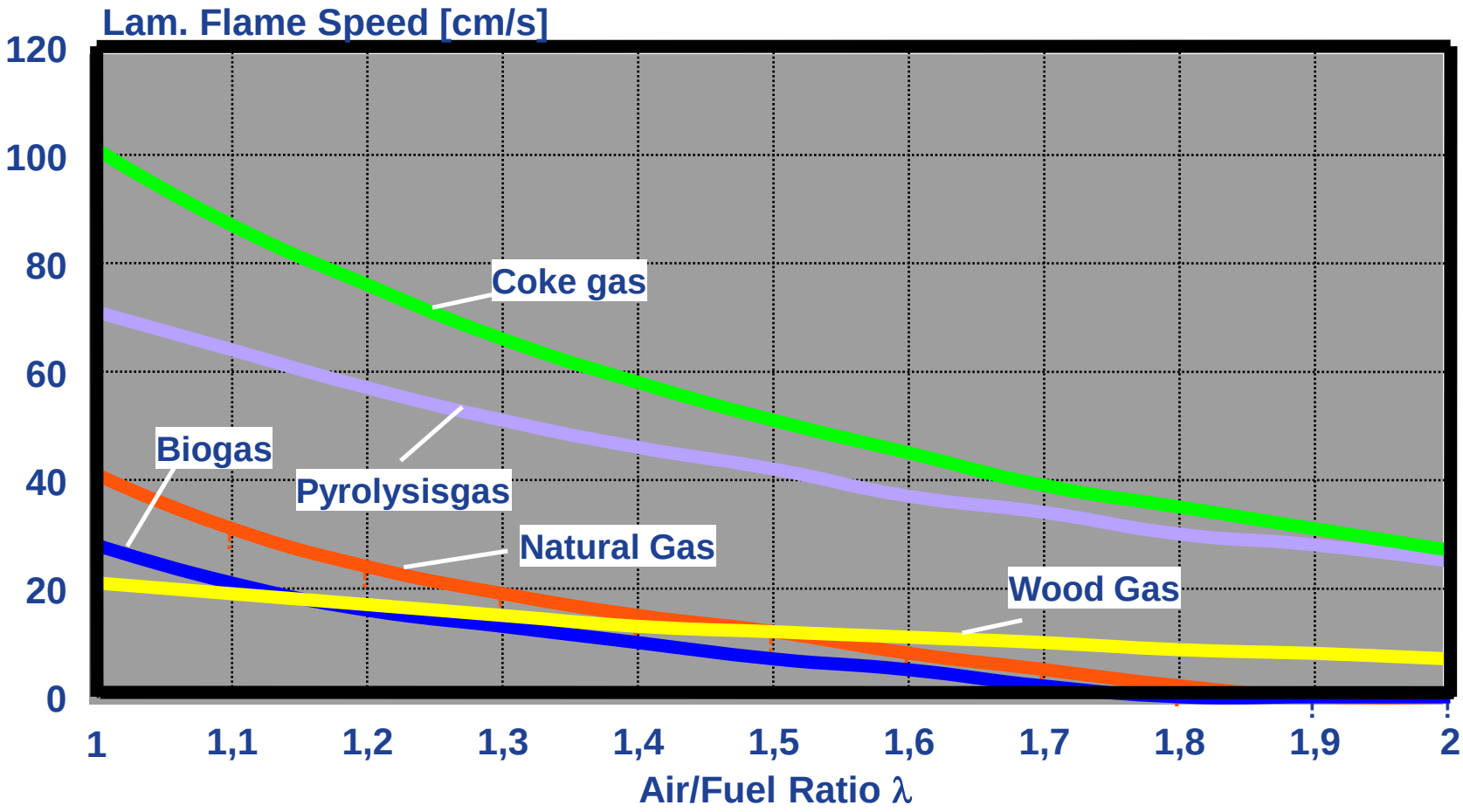
Laminar Flame Speed



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Critical issues Issues at Wood Gas CHP`s

ex. gas heat exchanger:
acid condensates

fuel gas pipe control line:
Condensates/sublimate resistant diaphrames resistant sealing elements

oxi catalyst:
gas cleaning

inter cooler:
condensates tar deposits

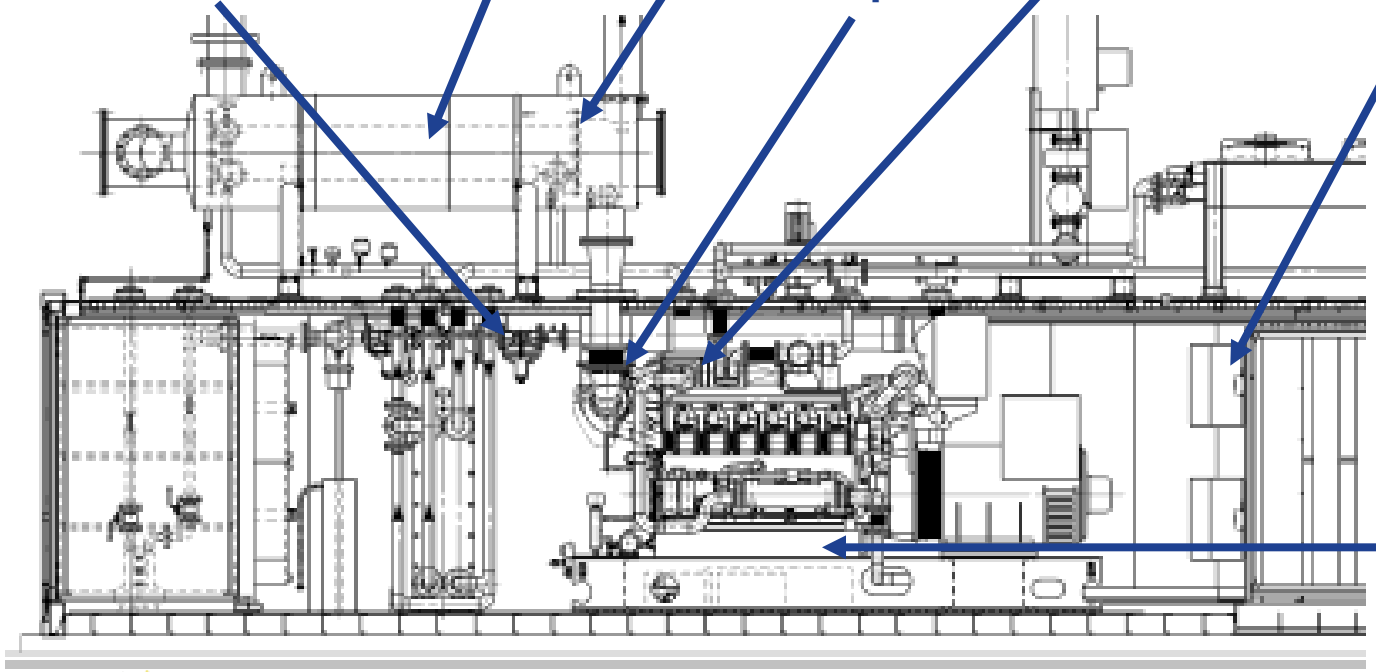
air conditioning:
condensates in the air/fuel system

turbo charger:
tar deposits

a/f ratio control:
NOx emissions backfiring

Saftety issues:
CO as gas component

engine oil:
acid components



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Crucial Points/Technical Barriers

Condensate

water

tar….

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Fuel flexibility

Landfill gas
Organic decomposition fuel gas
1 m ton of waste = 1 MW plant 15 yrs
1 million city = 8 MW

Coal mine gas
1 MW plant can displace more than 30,000 tons CO_2 per year

Sewage Gas
Fermentation fuel gas
0.5 milliion city = 1 MW

Cogeneration (Natural gas)

Flare Gas (Annual)
150 billion m^3 flared
1 MW = 2 m l of diesel

Industrial Gases

Biogas
Anaerobic digestion fuel gas
5,000 cows = 1 MW

Greenhouse

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QUESTIONS?