

Energy Sector – Industrial Power

SIEMENS

Serving Industry, Utility & Renewable Energy Customers

Workshop on Storage Systems for Renewable Energy

April 2010



Energy products and solutions – in 6 Divisions

**Oil & Gas/
Industrial**



**Fossil Power
Generation**



**Renewable
Energy**



**Energy
Service**



**Power
Transmission**

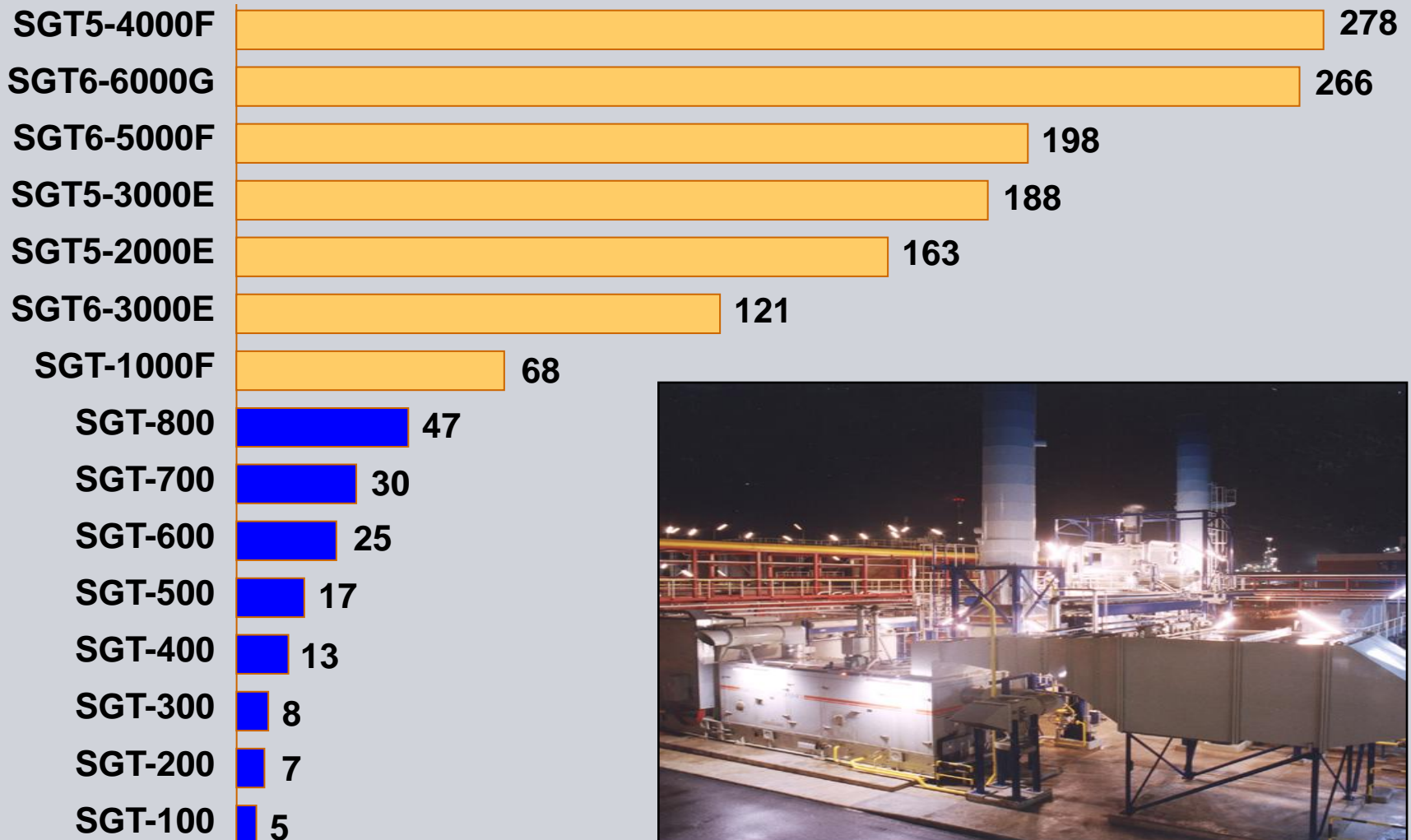


**Power
Distribution**



Gas Turbines for Utility & Industrial Applications

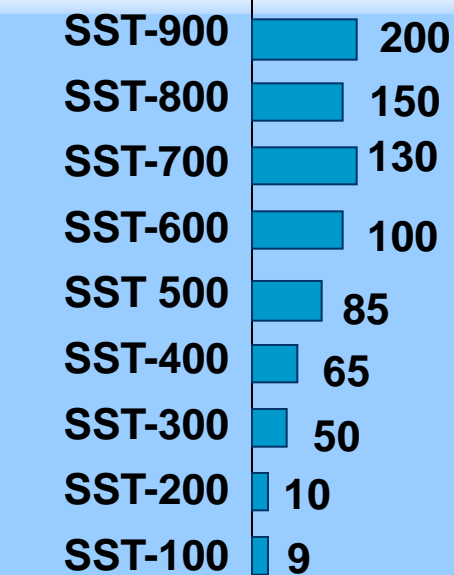
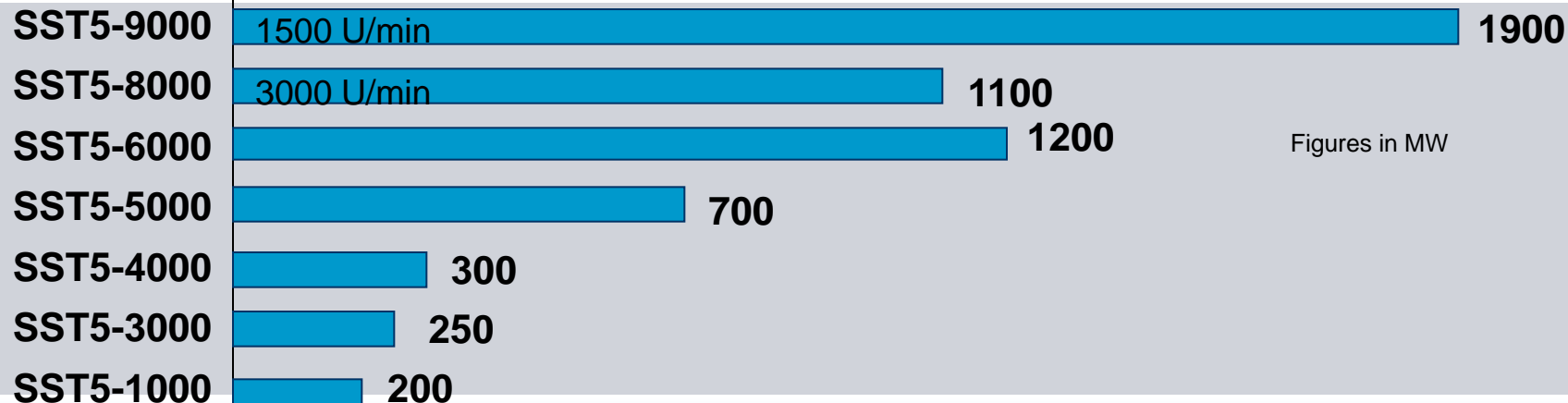
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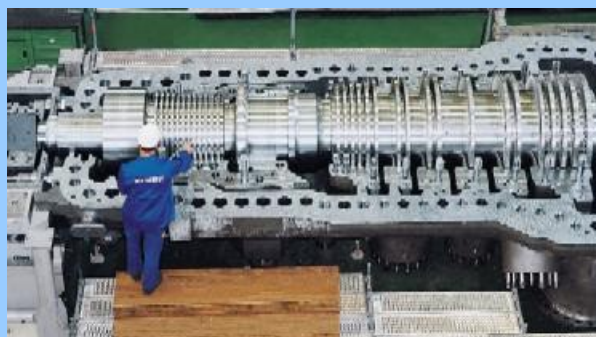
Integrated gas turbine portfolio

Steam Turbines for Utility & Industrial Applications

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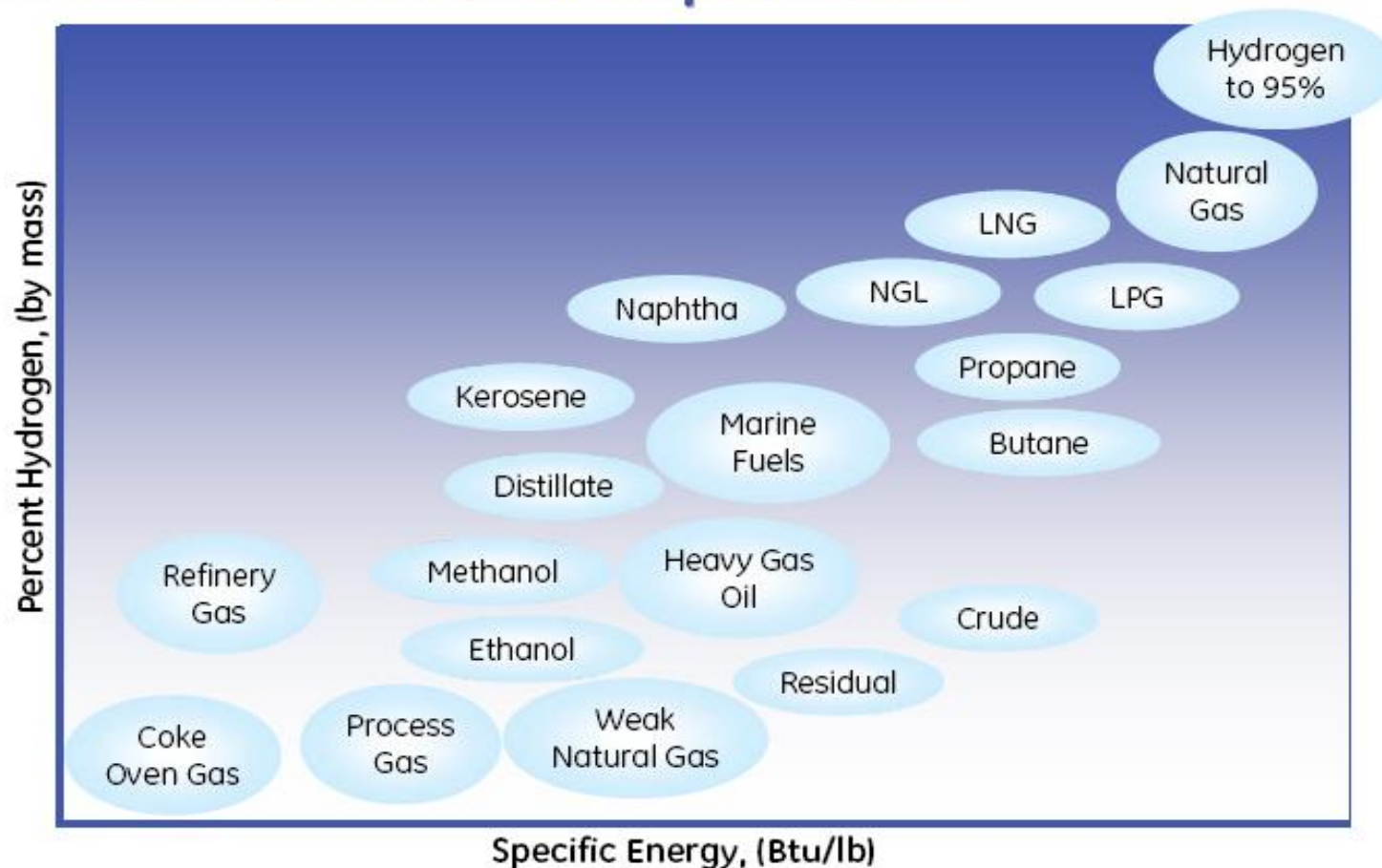


Industrial Scope

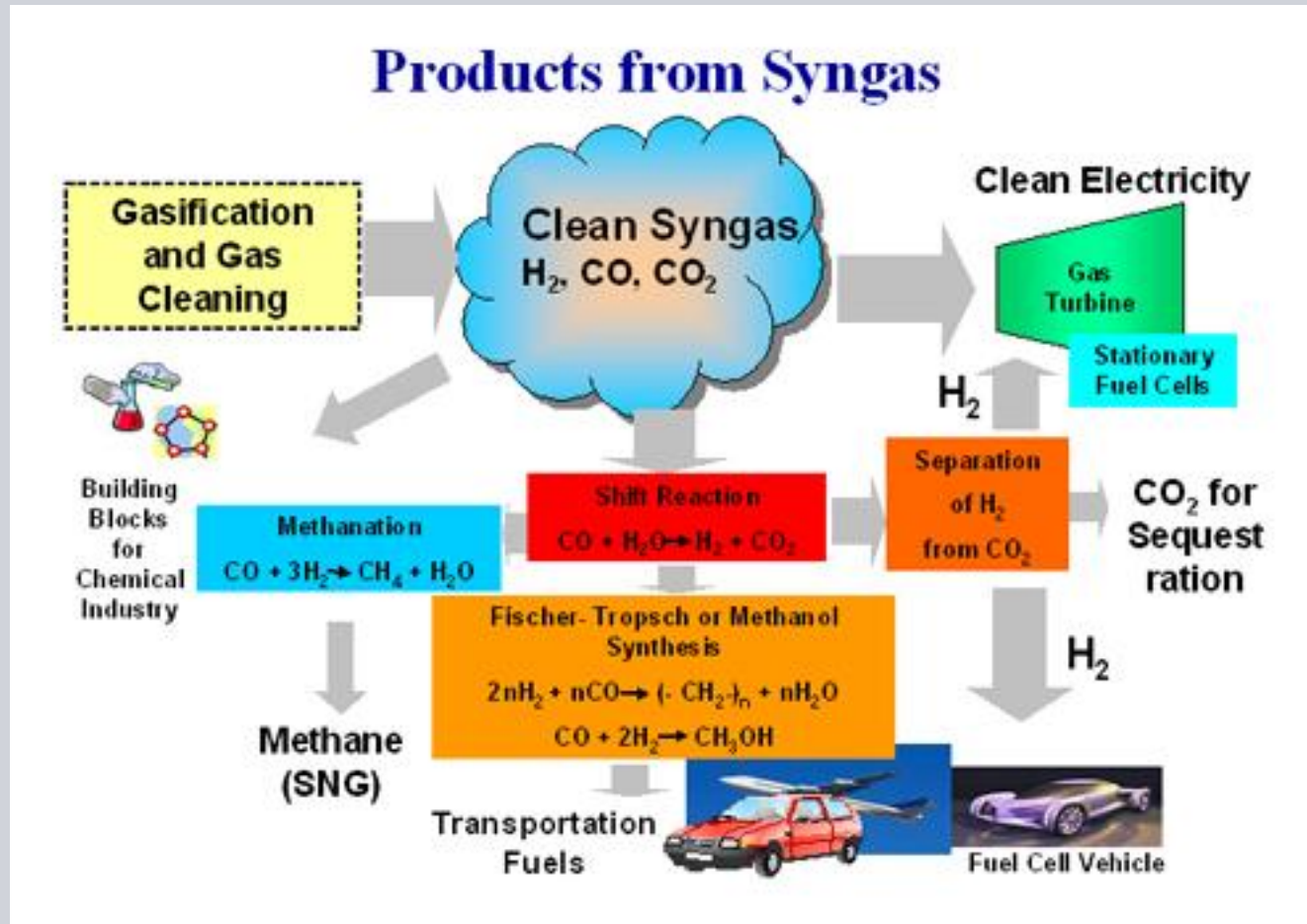


Hydrogen as Fuel for Combustion Turbines

Combustion Fuels Experience



DOE H2 Program – Part of “Clean Coal” Strategy



US DOE H2/IGCC Turbines Program

“The objective of this project is to design and develop a fuel flexible (coal derived hydrogen or syngas) gas turbine for IGCC and FutureGen type applications that meets DOE turbine performance goals.”

Hydrogen As Turbine Fuel

3 Effects of Hydrogen Combustion on Turbomachinery

Compared to natural gas, hydrogen combustion leads to a lower mass flow rate and to a different composition of the product gases, with an higher water content that in turn influences the molecular weight and the specific heat of the mixture. The most relevant effects on the operation of a gas turbine are: (i) a variation of the enthalpy drop in the expansion, (ii) a variation of the flow rate at the turbine inlet which, in turn, affects the turbine/compressor matching, (iii) a variation of the heat-transfer coefficient on the outer side of the turbine blades, affecting the cooling system performance.

Hydrogen As Turbine Fuel

Proceedings of GT2007
ASME Turbo Expo 2007: Power for Land, Sea and Air
May 14-17, 2007, Montreal, Canada

GT2007-28337

ADVANCED GAS TURBINE COMBUSTION SYSTEM DEVELOPMENT FOR HIGH HYDROGEN FUELS

Jianfan Wu, Phillip Brown, Ihor Diakunchak, Anil Gulati
Siemens Power Generation, Inc., 4400 Alafaya Trail, Orlando FL 32826-2399, USA

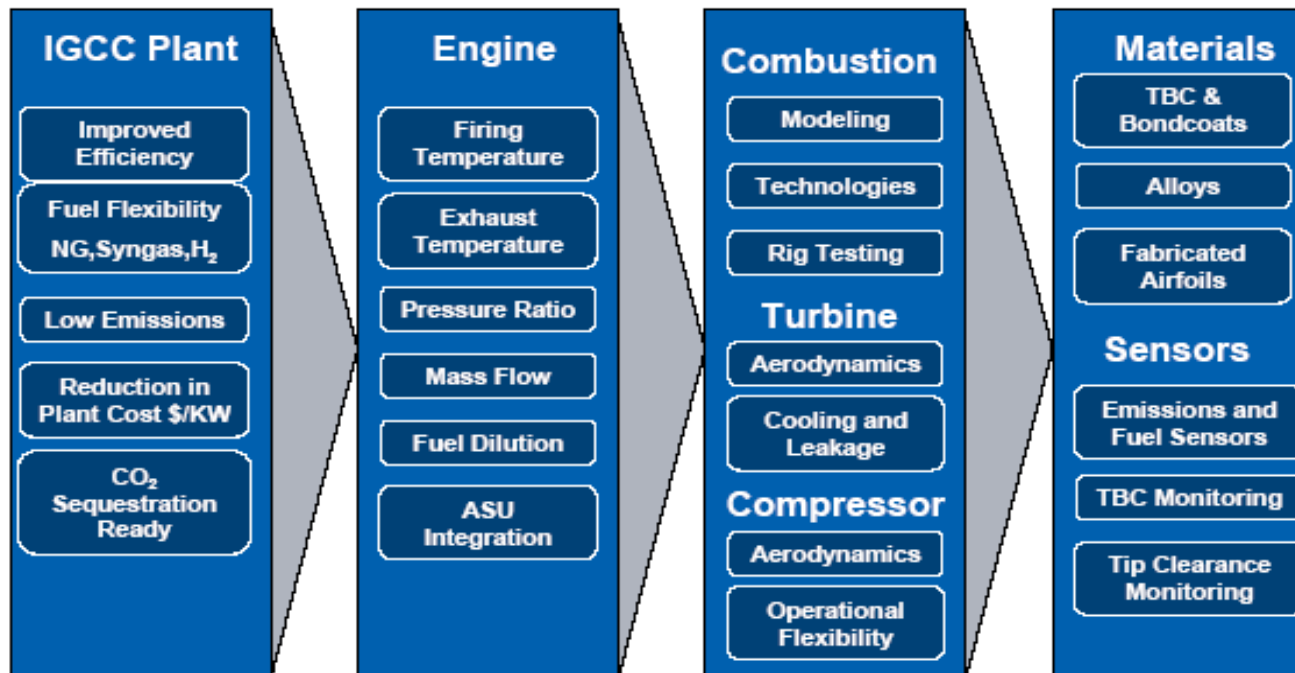
Martin Lenze, Berthold Koestlin
Siemens Power Generation, Inc., Mellinghofer Str. 55, Muelheim ADR 45473, Germany

Large Turbine Programs for H2

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Siemens – DOE Advanced H2 Turbine Program
Technology Development is Key to Meeting Program Goals

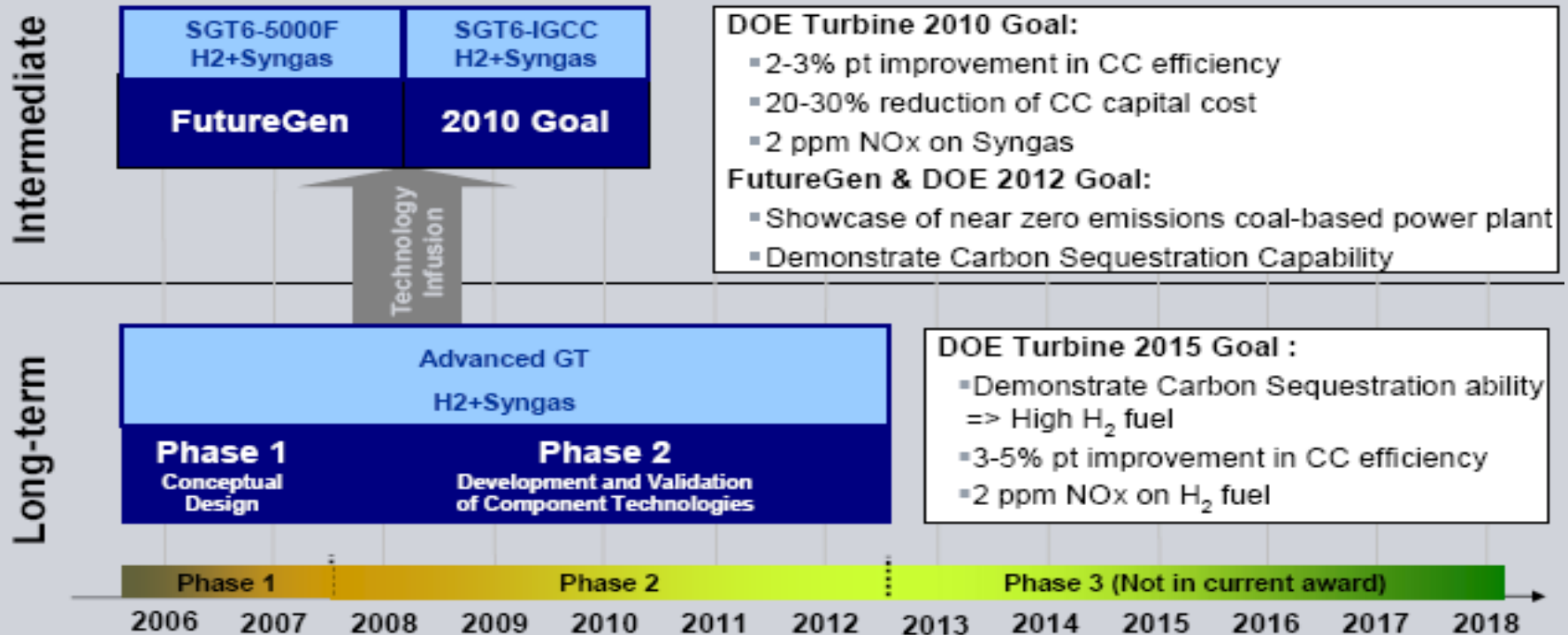
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Hydrogen As Turbine Fuel

4. Siemens / DOE Advanced Hydrogen Turbine

- Development Timeline



With the 2-step approach, DOE intermediate and long-term goals are addressed. Technology infusion from the Advanced GT to FutureGen & 2010 GT will be realized.

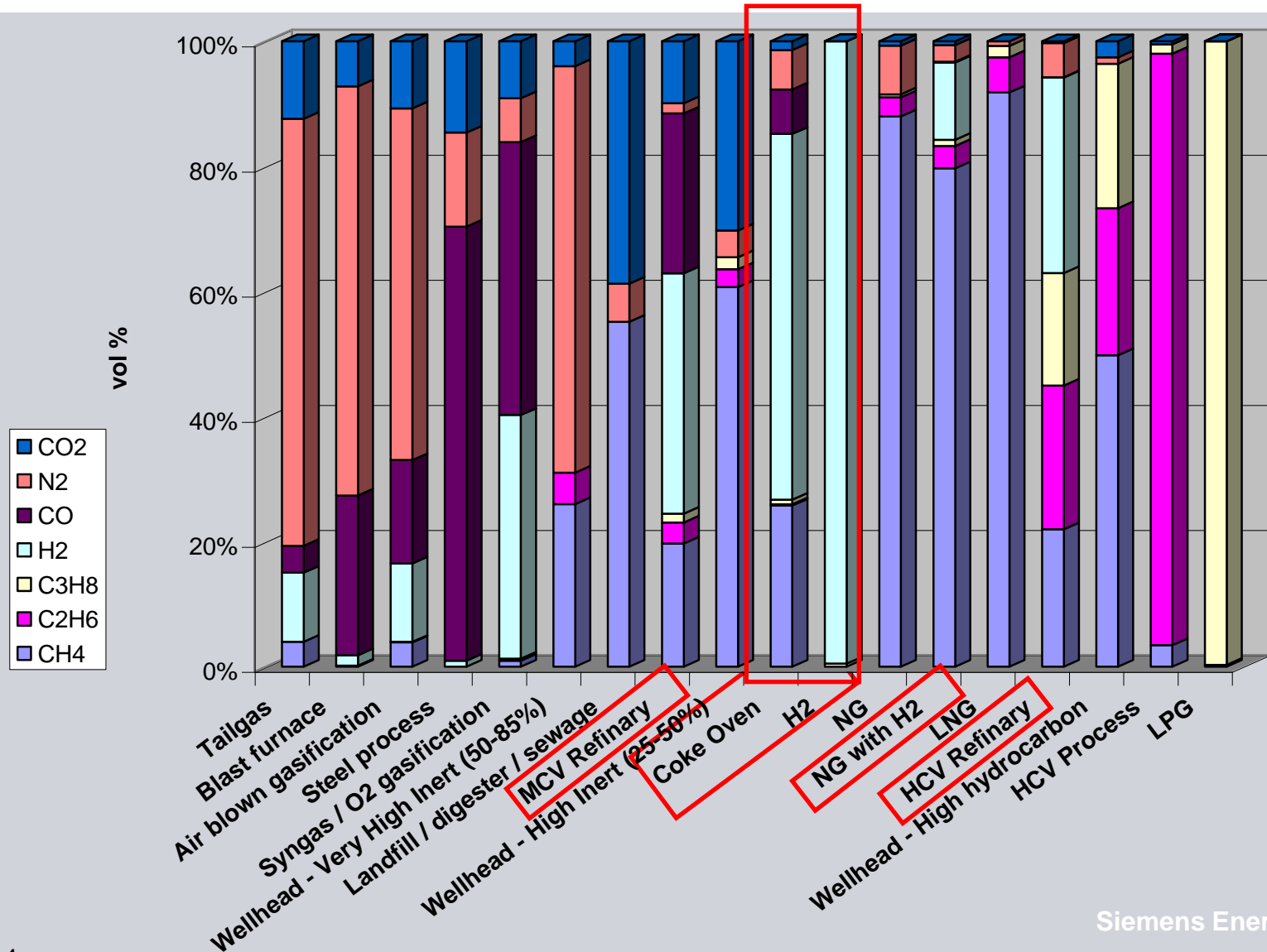
But....

Hydrogen Capability Currently Exists for Industrial Units

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- Siemens has considerable experience in refinery gas fuels containing high levels of H₂
- Some experience with Synthetic Fuels containing H₂ and CO; heavily diluted with Nitrogen (not commercial)
- Package changes necessary due to H₂ fuel
- Wet injection methods applied to provide exhaust emission suppression

Gas Fuel Species



Existing Turbine Capability for H2 Fuels

Gas Turbine	Plant Location	Main Features	Fuel	Startup
SGT-200	Many Locations		80-85% H ₂	
SGT-500/600	Many Locations		20-90% H ₂	
VM5	Dortmund, Germany	Compressor Drive GT	Blast-Furnace Gas	1960
VM5	Handan, China	Compressor Drive GT	Blast-Furnace Gas	2000
CW201	Chicago, USA		Blast-Furnace Gas	1960
V93	Luenen Germany	First CC plant in the world with integrated LURGI coal gasification	Syngas	1972
2XSGT6-3000E	Plaquemine, USA	CC plant with integrated DOW coal gasification	Syngas	1987
4XSGT6-3000E	Sweeney Cogeneration L.P., USA	CC Plant	0 – 30% H ₂	1998
SGT5-2000E	Buggenum, Netherlands	CC plant integrated with coal gasification (hard coal and biomass blend)	Syngas	1994/5
V94.3	Puertollano, Spain	CC plant integrated PRENFLO coal gasification (coal and petroleum coke blend)	Syngas	1997/98
2XGT5-2000E	Priolo Gargallo, Italy	CC plant with integrated GE heavy-oil (asphalt) gasification	Syngas	1998/99
SGT5-2000E	Servola, Italy	CC plant with steel-making recovery gas	Steel-Making Recovery Gas	2000
SGT5-2000E	Sannazzaro, Italy	CC plant with integrated SHELL heavy-oil gasification	Syngas	2005

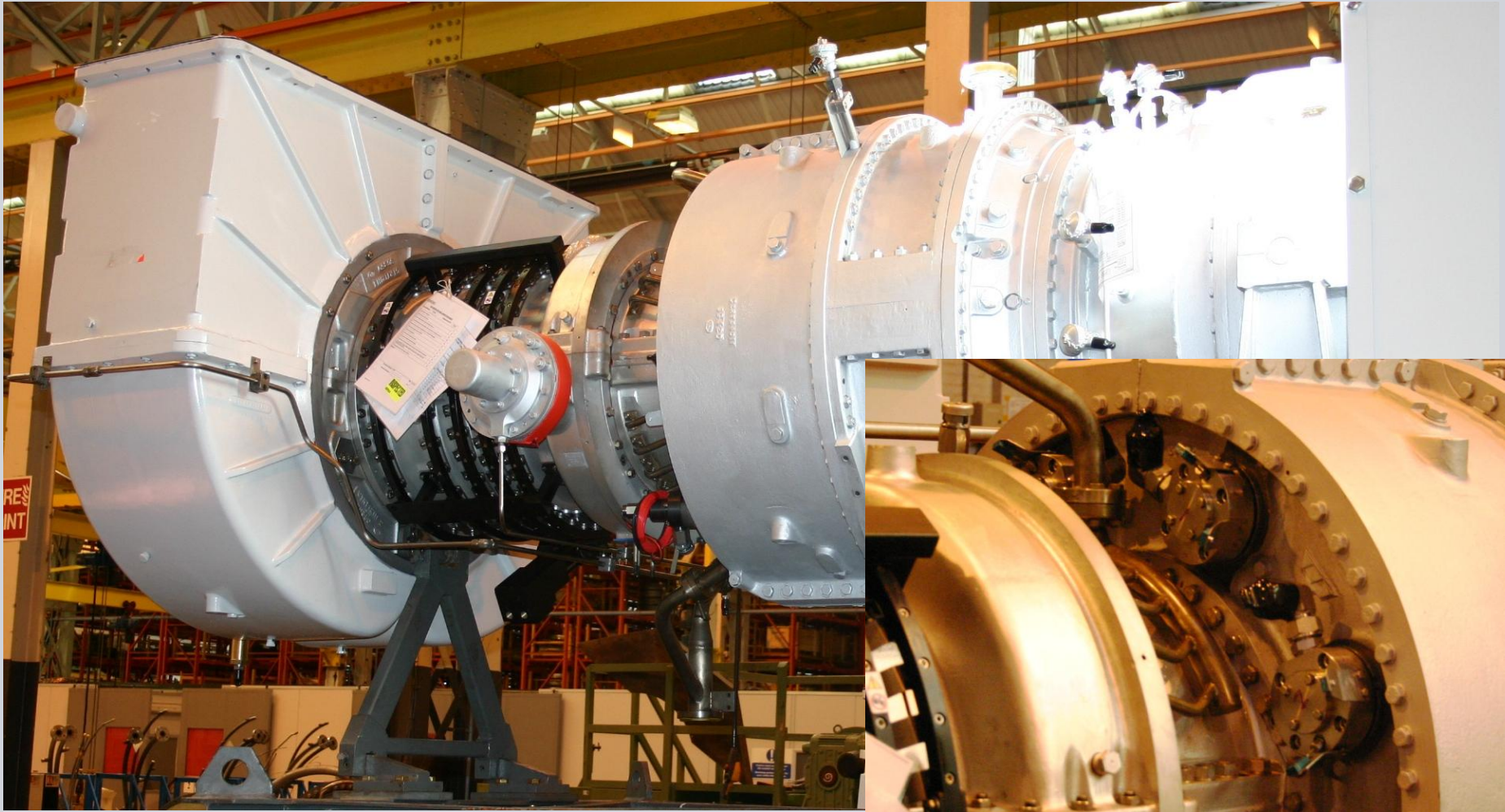
Table 1. Operating Experience with Syngas and Hydrogen Fuels

Experience with Hydrogen

High Hydrogen Fuel Applications (up to 85% H2 vol%)				
Customer	Location	Driven Unit	CHP	Combustion Configuration
Taiyo Oil	Japan	Gen	Yes	Dual fuel
Petromed (BP Oil)	Spain	Gen	N/A	Gas
Gulf Oil	UK	Gen	Yes	Dual Fuel
Gulf Oil	UK	Gen	Yes	Dual Fuel
Gulf Oil				
ESB Tran				
Powergen				
Powergen Conoco	UK	Gen	Yes	Gas
Powergen Conoco	UK	Gen	Yes	Gas
Powergen Conoco	UK	Gen	Yes	Gas

Total Running Hours > 600,000 With
 H2 > 65%

SGT-200-1S Hydrogen Application (COG)



Package Consideration

Hydrogen Embrittlement

- Ensure fuel system pipework and fitting of suitable material
- Martensitic steels particularly susceptible
- Stainless steel (“300” series) used as standard (pipework and fittings)

Hydrogen Use For Power Production ?

Conclusion

▪ **Wait**

- ❖ DOE's long-term program for use of H₂ fuel (from coal) in large-scale utility power projects

▪ **Don't Wait**

- ❖ Use commercial products suitable for high-content H₂ fuel in industrial-sized Distributed Generation/ Cogeneration
- ❖ Allows proof of concept for high H₂ content fuels
- ❖ Provides high efficiency projects for municipalities, universities, etc.