Diagnostics Challenges in SOFC Systems

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Outline of the presentation

- Wärtsilä and Wärtsilä Fuel Cell Program
- Fuel cell systems and their diagnostic challenges

WÄRTSILÄ

“The leading global provider of power solutions to the energy and maritime sectors”

- History of 175 years
- Over 19 000 employees
- 2008 net sales 4 612 M€
- 2008 operating income 525 M€ (11,4%)

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The Wärtsilä fuel cell program

- Wärtsilä's fuel cell R&D program is to develop and commercialize SOFC based power units for distributed power generation and for marine auxiliary power
- We focus on design and engineering of fuel cell systems. System integration and application know-how are key areas where Wärtsilä's expertise is utilized
- Wärtsilä has operated integrated WFC20 prototypes and plans to demonstrate first field units in the 20 kW power class in 2009
- Development of larger units in the 50 - 250 kW power range are planned to follow 2009-

Wärtsilä Fuel Cell Program

WFCG: history and today

- FC Pre-Study — 2000
- FC Feasibility study — 2001
- SOFC conceptual study — 2002 - 2003
- Business plan — 2003 - 2004
- 1-5 kW SOFC test system — 2004 - 2006
- WFC20 kW α-prototype — 2005 - 2007
- WFC20 Proto II — 2007 - 2009
- WFC20 Vaasa HF — 2007 - 2009
- WFC20 METHAPU — 2007-2009
- WFC50 Large SOFC — 2008 - 2010
- WFC50 Demo-SOFC — 2008 - 2010

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Application areas and customers

Short route ferries, car carriers, cruiser

Biogas from Landfills,
Waste water and farms

Telecom/data centers, Hospitals, Banks

Hotels, malls, offices, industries

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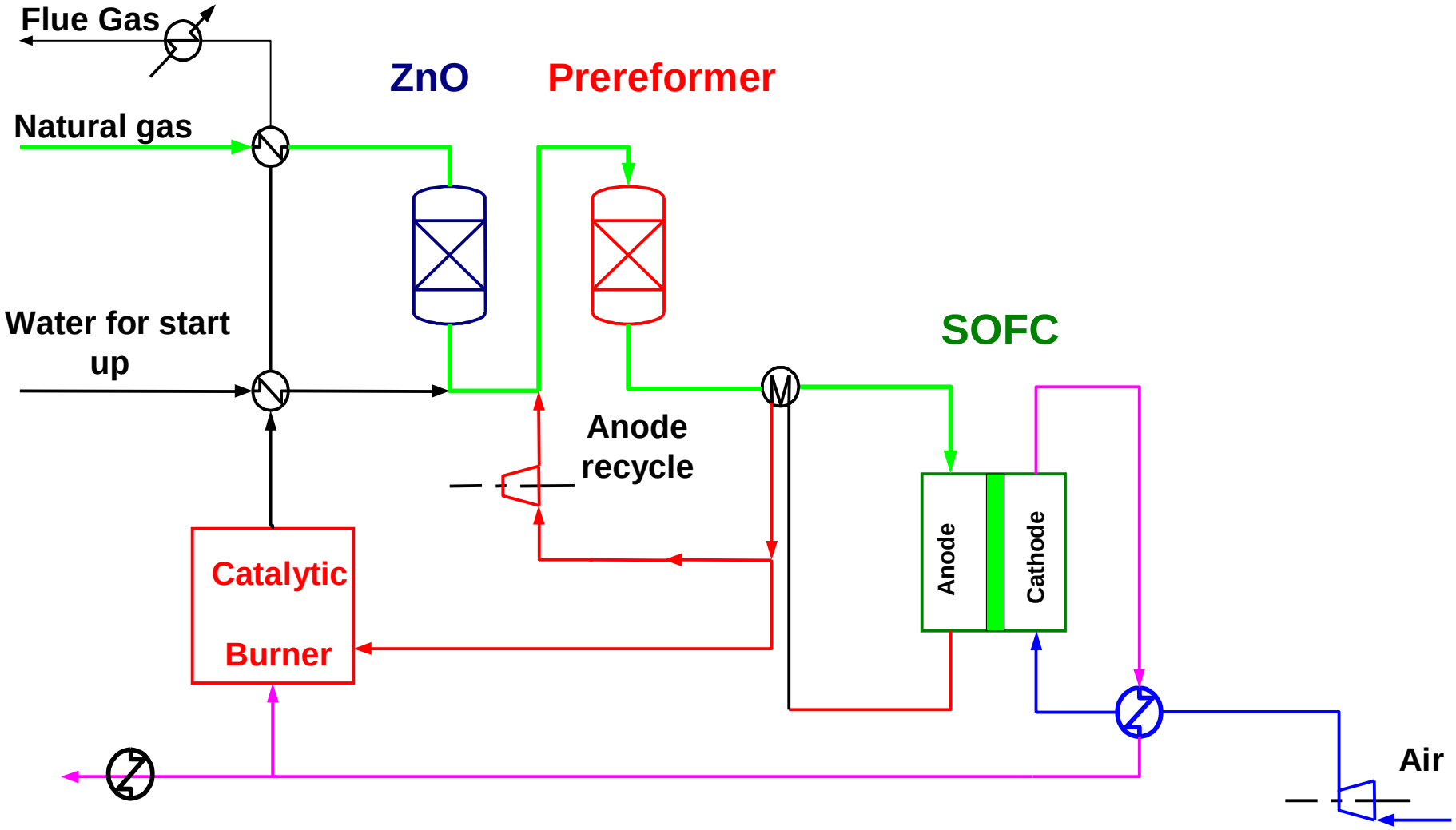
Fuel cell process flow diagram

NG fuelled SOFC concept



Diagnostic challenges

- The controls of a typical fuel cell system are based on normal process measurements (thermocouples, pressure transmitters, mass flow indicators/controllers, voltage, current….)
- In some cases more “exotic” measurements are required (gas composition, humidity ….
- Basic requirements for sensors
  - Easy to mount/install, maintenance free/easy to service
  - Cost efficient (at the moment the stack suppliers recommend massive instrumentation for stack control -> constituting a major cost issue)
    (e.g. one thermocouple costs ~10 €, but with installation and connection to PLC, the overall cost could be several hundred euros)
  - Reliability (System MTBF min 3000-4000 h)
- Challenges specially arise from the sensing of hot parts of the system
  - Expensive materials
  - Durability issues
  - Hot lead-troughs are mechanically challenging, causes excess thermal bridging and are highly expensive

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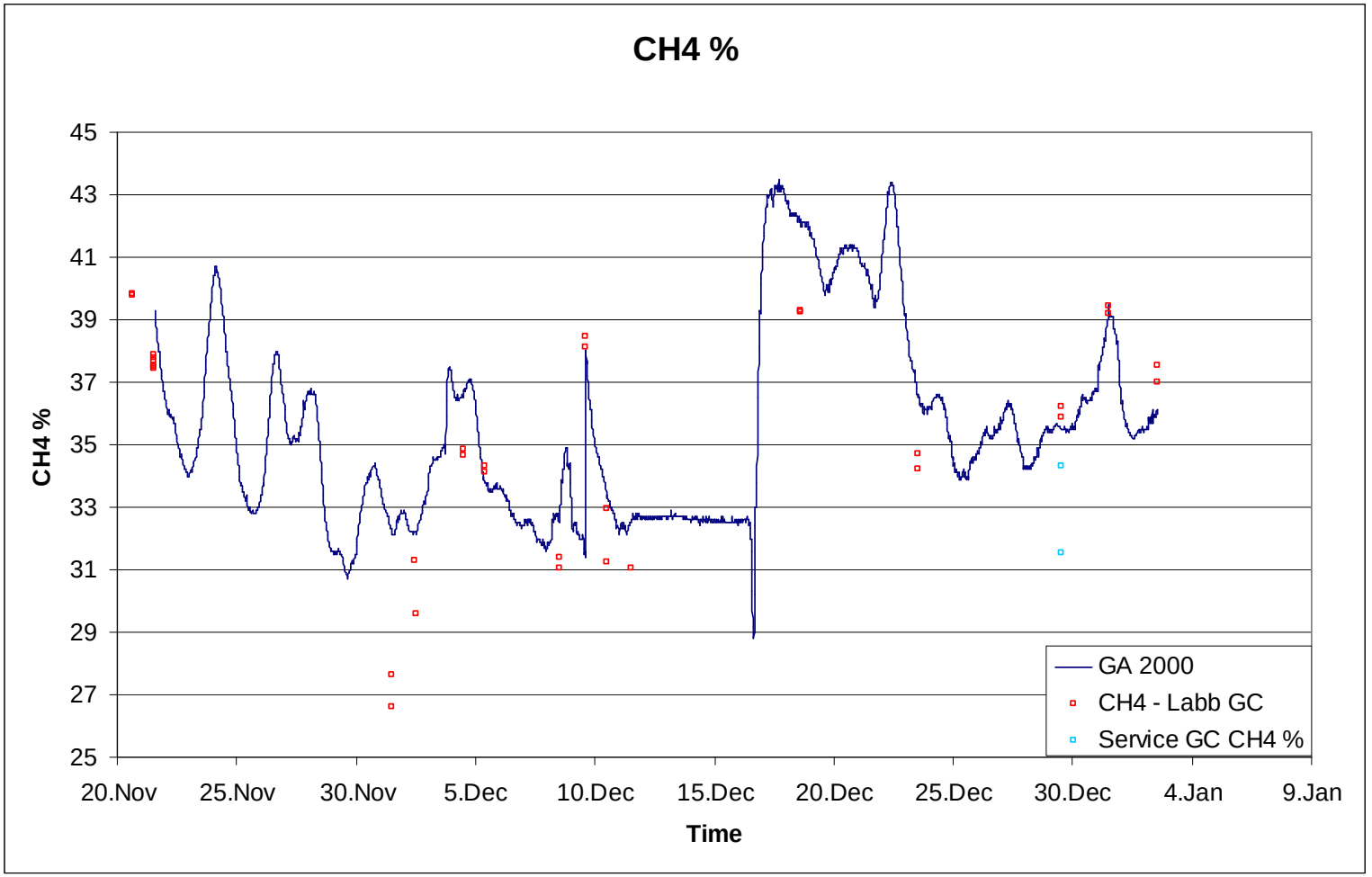
Measurement challenges

- The control of the anode recycle is a significant measurement challenge
  - This control is critical with respect to system efficiency (FU) and coking restraint (O/C)
  - Is typically based on a “known” volumetric flow and calculated equilibrium composition
  - On-line composition measurements are costly and extremely challenging at high temperatures
  - The exact measurement of the real volumetric/mass-flow with changing composition is challenging
  - Direct measurement of O/C-ratio would simplify control as FU is not as critical as O/C)

- The control of the fuel feed in biogas applications poses very similar challenges

- Gas flow temperature measurements is challenging at high temperatures
  - No practical means available to eliminate radiative heat transfer from hot surfaces
  - Available alternatives are improved insulation, turbulence elements or radiation shielding elements.
  - Accurate temperature measurements would be necessary in order to detect hardware performance changes as well as to utilize state-estimates for process control
  - State-estimate based stack models based on measured process data would be highly desirable for system control, but require accurate temperature measurements.

Measurement challenges, landfill gas methane content



Thank you for your attention