Sixth Annual Conference on Carbon Capture & Sequestration

Capture – Advanced Concepts

CO2 CAPTURE USING DENSE HYDROGEN TRANSPORT MEMBRANES

Doug Jack, David Anderson, Carl Evenson, Michael Mundschau &

Richard Mackay – Eltron Research & Development, Inc

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CO_2 Emissions On The Rise

- EIA Projects over the period 2003 – 2030
  - World annual electricity demand will more than double
  - Leading to a doubling of coal consumption
  - Oil will also rise nearly 50%
- More production from Canadian tar sands

CO_2 emissions are expected to rise from ~25 billion metric tons to over 43 billion annually

Ref: Energy Information Administration, Office of Integrated Analysis and Forecasting, U.S. Department of Energy, "International Energy Outlook, June 2006

Carbon Capture Methods

- Post-Combustion
  - Remove CO_2 from combustion exhaust gases
- Oxy-Fuels
  - Fire combustion with O_2 instead of air
  - Remove CO_2 from combustion exhaust gases
- Pre-Combustion
  - Convert fuel to CO_2 and H_2, remove CO_2 before burning

Pre-Combustion Separation Methods

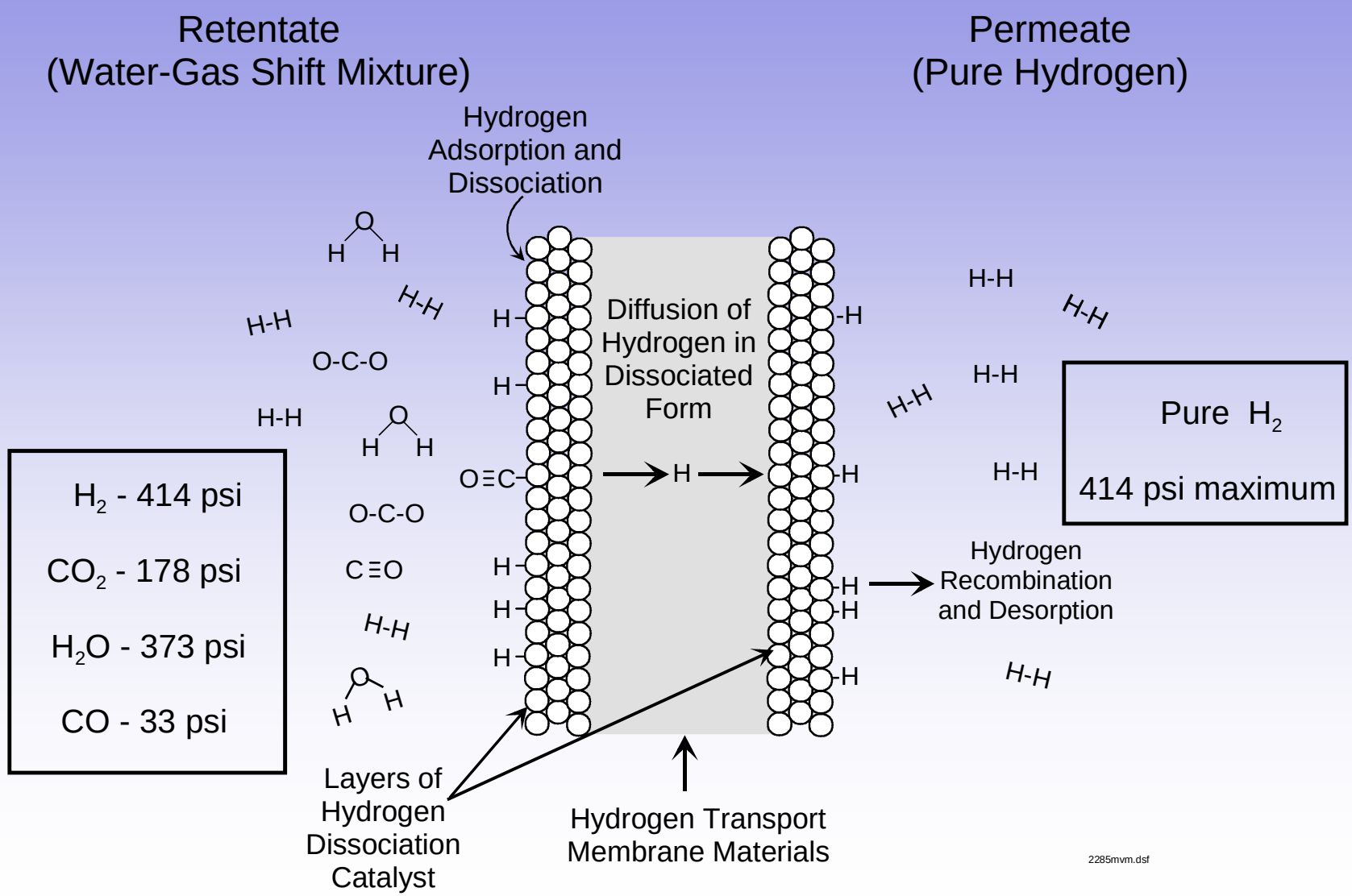
- Amine/Solvent Absorption
- Micro-Scale Filtration
- Pressure Swing Adsorption
- Dense Membranes
  - Ceramic
  - Metallic
  - Composite (e.g., Cermets)

Eltron HTM Project Goals

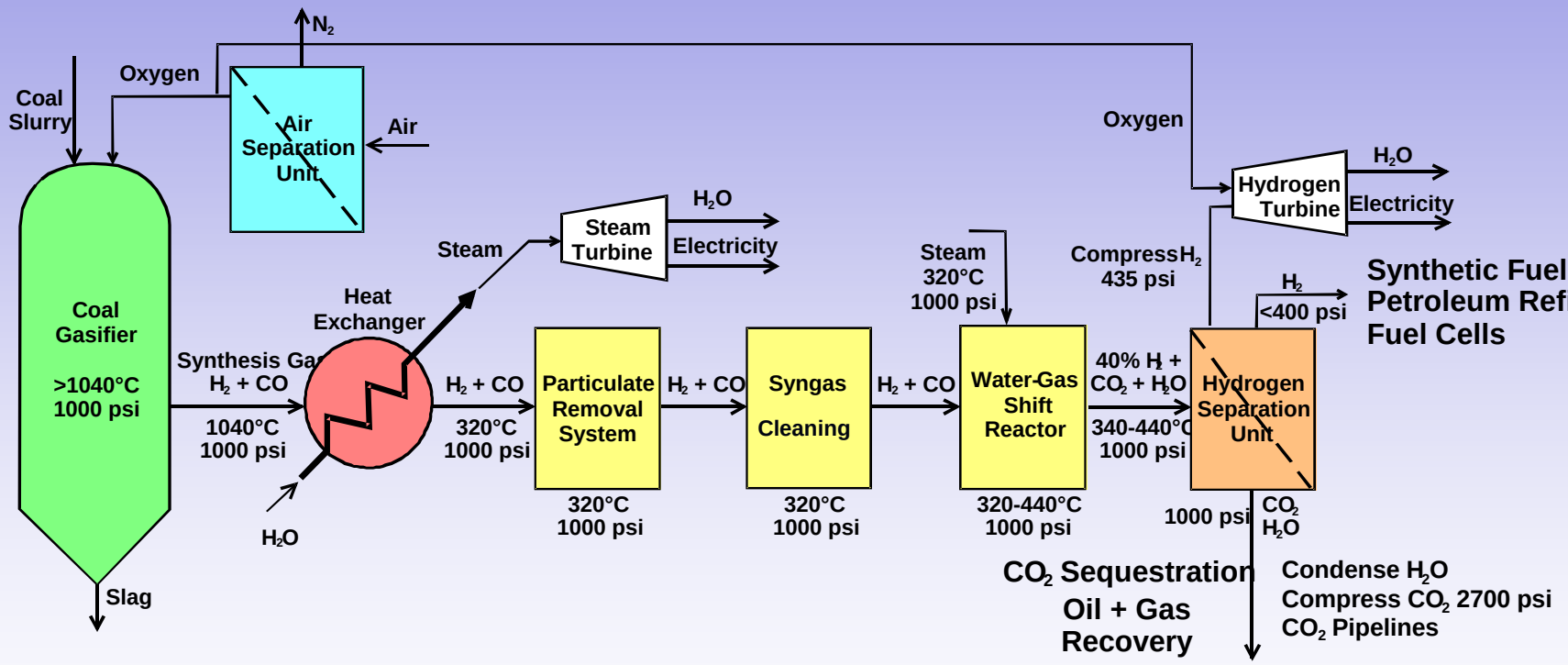
- Develop H_2/CO_2 Separation System, which
  - Retains CO_2 at coal gasifier pressures (450-1000 psig)
  - Operates near water-gas shift conditions (T, P, gas composition)
  - Tolerates reasonably achievable levels of coal-derived impurities
  - Delivers pure H_2 for use in fuel cells, gas turbines, and hydrocarbon processing
  - Is cost effective compared to alternative technologies for carbon capture

Eltron Project being funded through DOE

Membrane Fundamentals



Role of Hydrogen Separation Membranes in CO_2 Sequestration



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Technology Development Highlights

- Demonstrated a membrane system based on metallic alloys that meets or exceeds the 2010 DOE performance targets
- Developed cermet materials with comparable performance to Pd membranes
- Results from process economic studies show that this system is competitive with conventional technology
  - Reduced cost of electricity
  - Improvement in thermal efficiency
- Operating 1.5 lbs/day pilot plant

Progress Towards DOE FutureGen Targets

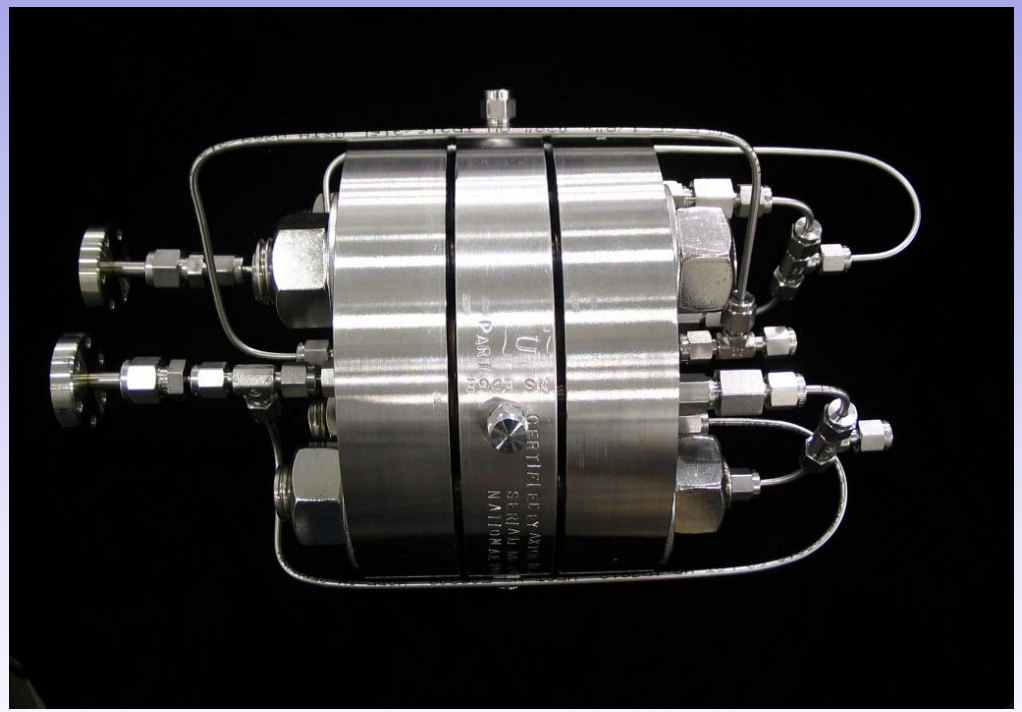
Performance Criteria	*2005 Target*	*2010 Target*	*2015 Target*	*Current Eltron Membrane*
Flux (sccm/cm^2/100 psi ΔP)	50	100	150	160
Operating Temperature (^{o}C)	400-700	300-600	250-500	300-400
S Tolerance (ppmv)	N/A	2	20	20 (early)
System Cost ($/ft^2)	1000	500	<250	<200
ΔP Operating Capability (psi)	100	400	800-1000	1,000
Carbon monoxide tolerance	Yes	Yes	Yes	Yes
Hydrogen Purity (%)	95	99.5	99.99	>99.99
Stability/Durability (years)	1	3	>5	0.9
Permeate Pressure (psi)	N/A	N/A	N/A	270

High Pressure Reactor – Eltron Research

- Pressures up to 1000 psig
- Tests in Water-Gas Shift Mixtures

- Eltron has only facility in U.S. capable of testing hydrogen transport membranes under extreme pressure conditions.

Small Pilot Scale Testing Module

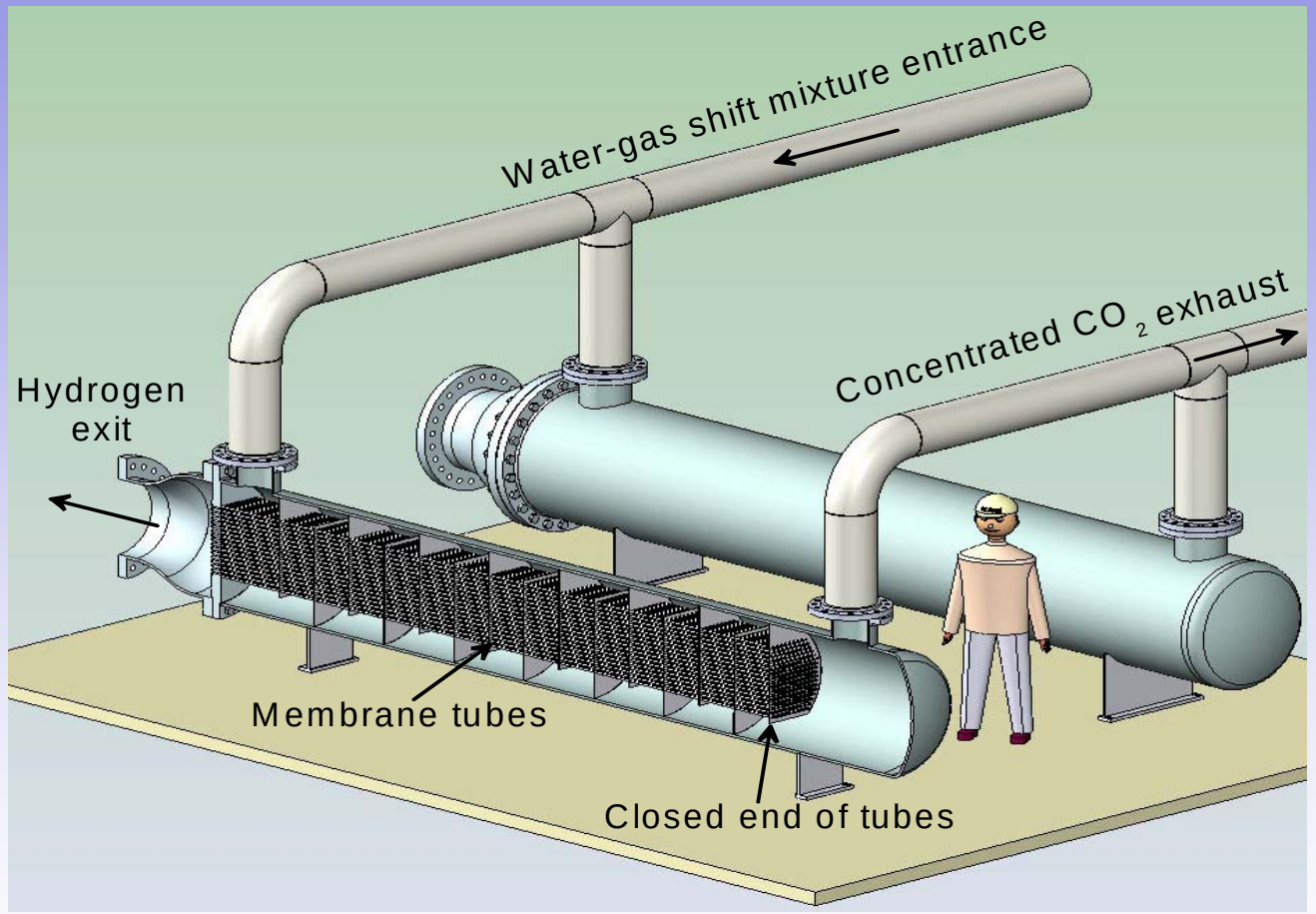


1.3 lbs H_2 / day Separation Unit Designed by NORAM

Current Focus

- Understanding factors affecting longevity of membrane systems
  - Embrittlement
  - Life
- Scaling up manufacturing techniques
  - Tubular versus planar
  - Other mechanical issues (welding, sealing, etc)
  - Catalyst deposition
- Tolerance to impurities
- Process optimization

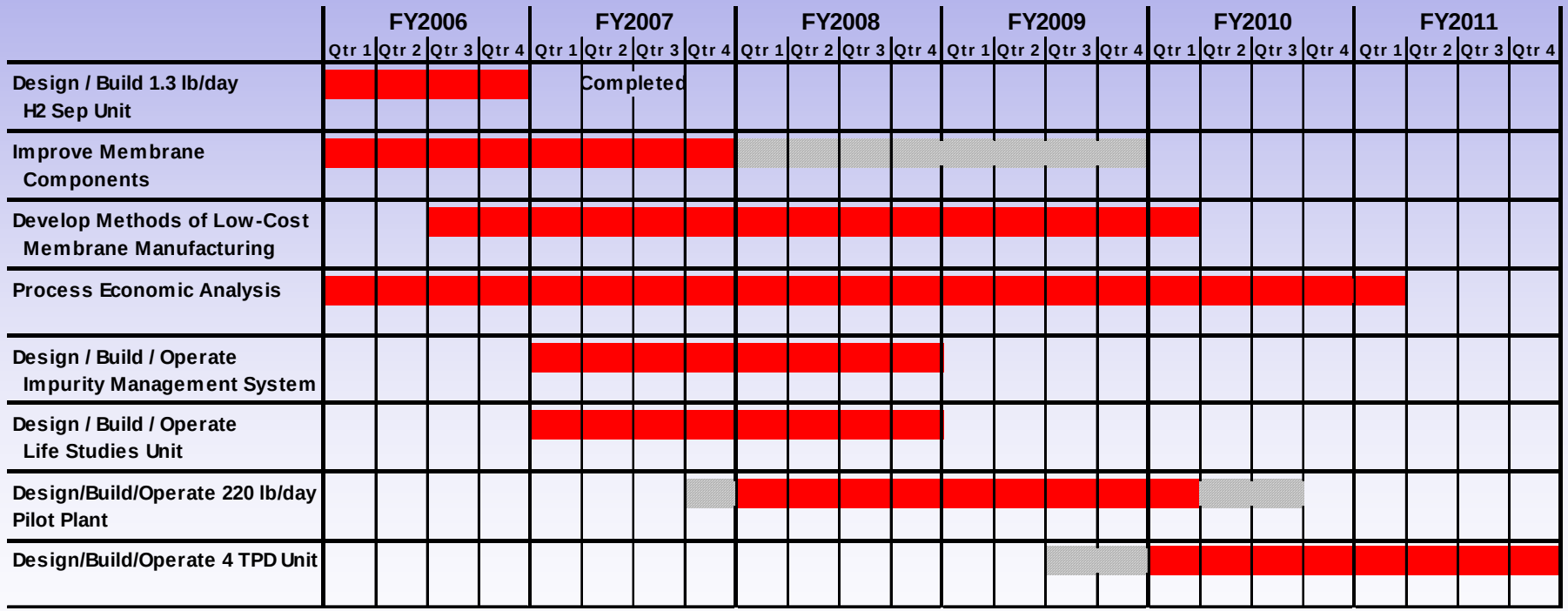
Scale-Up Designs – Tubular (NORAM)



- **NORAM conceptual tubular design of a commercial membrane unit capable of separating 25 tons per day (~10 MMSCFD) of hydrogen. Sizing is based upon syngas at 1000 psig (68 barg), 450°C, 50 vol.% H_2 in feed.**

Simplified Project Schedule

Scale Up Hydrogen Transport Membranes for IGCC and FutureGen Coal to Hydrogen Production Plants



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