

the Energy to Lead

Natural Gas Applications: Technology Challenges, Current Status and Future

-
- > Jack Lewnard, Bill Liss, and Eddie Johnston
 - > RPSEA Natural Gas Path to Clean Energy

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Outline

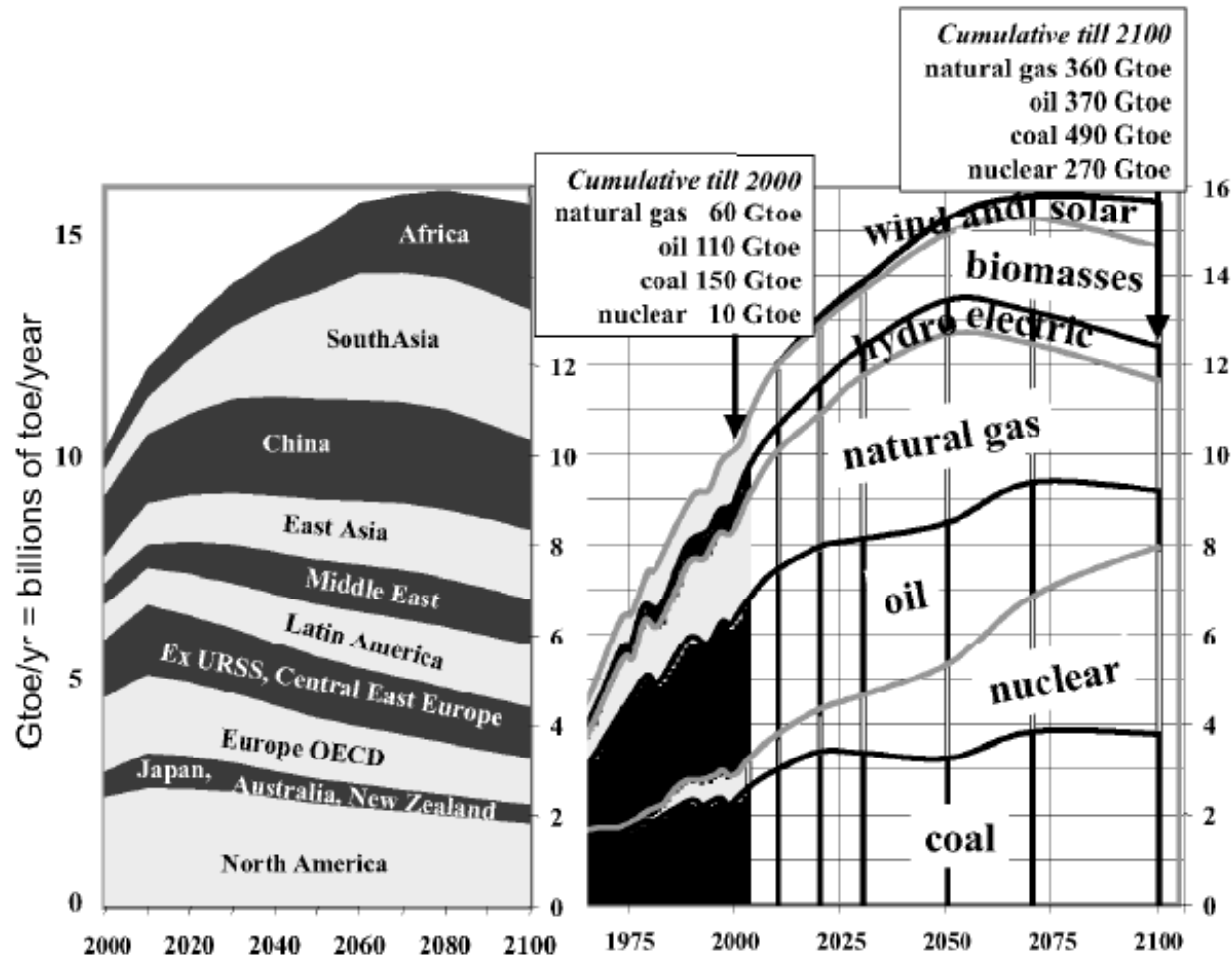
- > Role of natural gas in a low-carbon future
 - Role in the energy mix
- > Gas to de-carbonize US economy
 - How we use gas
 - Near-, Mid-, and Long-term options
- > Managing energy holistically
 - Smart *Energy* Grid
 - Life Cycle Analysis
- > Closing thoughts

Gas applications: Where we've been, Where we're going

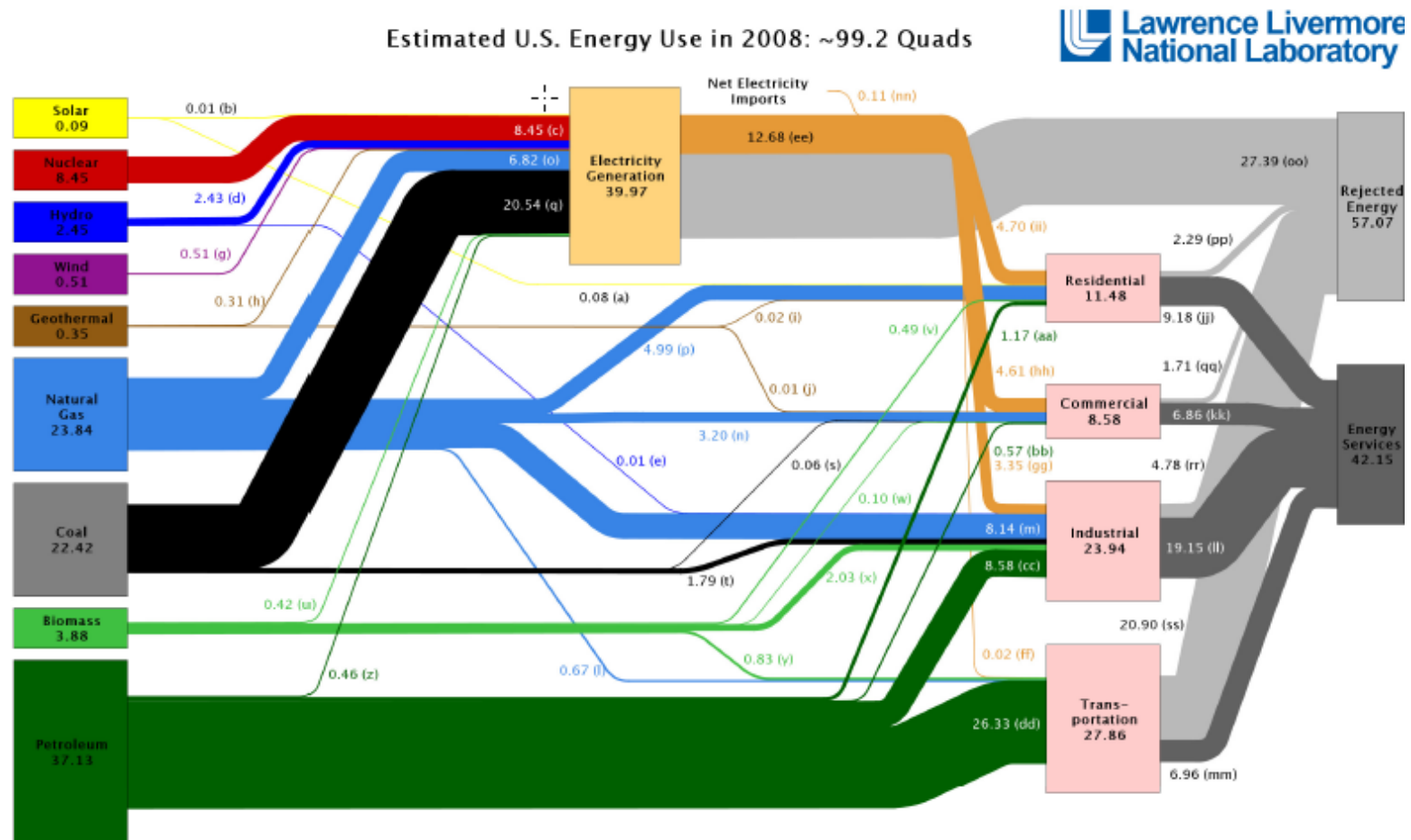
- > Historic fossil and renewable gas applications
 - Natural gas seep powers the Oracle of Delphi, 1400 BC
 - Biogas fires Assyrian baths, 100 BC
 - Piped town- and fossil- gas commercialized in 1800's to light homes, businesses, streets, and banish darkness
- > More recent history
 - Large-scale use begins in 1920; expanded during WWII and thereafter
 - Unique - in every economic sector (residential, commercial, industrial, agricultural, chemical feedstock, power, transportation, etc)



Gas in the Global Energy Mix



Energy in the US: Where it comes from, where it goes



Natural Gas End Use: A Vision for Today and the Future

American Gas Foundation 2009

> Natural Gas End-Use Vision

- Clean, abundant, efficient, American, relevant today and in the future

> Specifies RD&D Priorities and Funding, with targeted CO₂ reductions

- Homes and Businesses
- Industrial Applications
- Transportation

**Table 1. Reduction in Greenhouse Gases per Year
(Million Metric Tons CO₂ e)**

GHG Reductions (Million Metric Tons CO₂ e)			
RD&D Portfolio	2015	2020	2030
Homes and Businesses	36	101	289
Industrial Applications	10	42	105
Transportation	5	16	40
Total	51	159	434

Role for Natural Gas

Near Term: Rationalize Energy Use

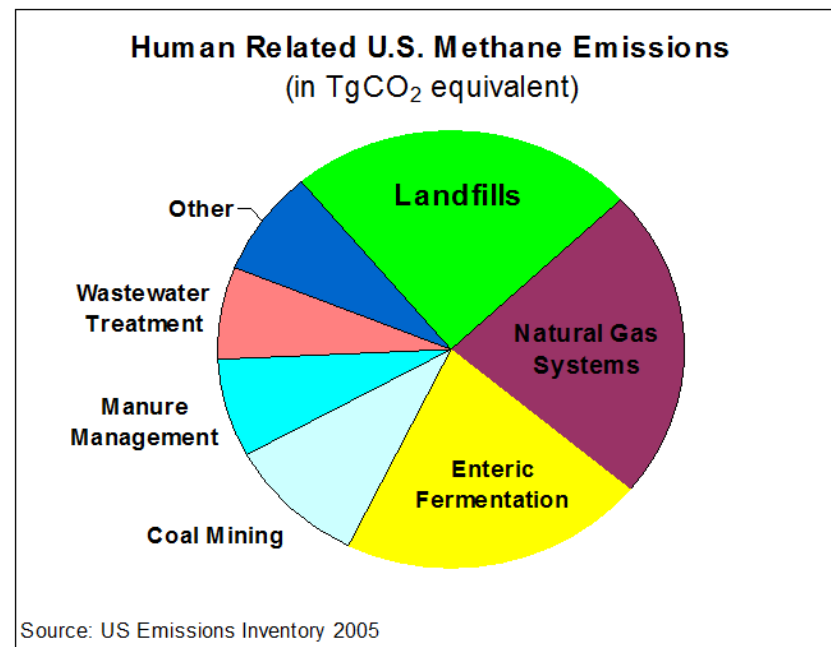
1. Displace of electric resistance appliances for space and water heating, clothes drying, rangetops and ovens; CO₂ reduction 89-134 MM tons/year
2. Replace of older, less-efficient gas appliances for space and water heating, and boilers; CO₂ reduction 65–97 MM tons/year
3. Replace less-efficient, higher CO₂-footprint oil-fired space and water heaters, and biolers; CO₂ reduction 9-29 MM tons/year
4. Increased combined heat and power (CHP), with heat for district heating and cooling; water heating, process heating and steam generation; CO₂ reduction 60-90 MM tons/year

Mid-Term: Reduce Footprint, NGV's

1. Reduce methane leaks from production, processing, compression, transmission, and distribution 50% by 2030; CO₂ equivalent reduction 66–99 MM tons/year
 - INGAA study also identified potential for 500-600 MW from gas compressor waste heat
2. Achieve NGV America's goal: displace 10 B gal oil/year with 2.7 MM light, medium, and heavy-duty NGV's; CO₂ reduction 16–24 MM tons/year

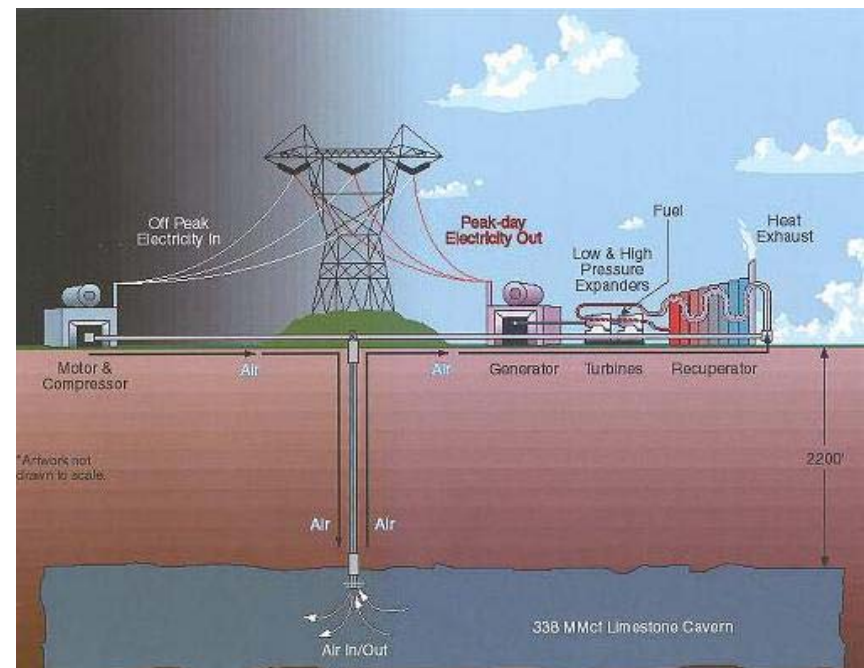
Long Term: Renewable Gas Mixes

1. US EPA estimates 1-2 TCF recoverable biomethane; CO₂ reduction 10 MM ton/year
2. Biomass-to-SNG potential 10 TCF; highest energy conversion option for biomass; CO₂ reduction >100 MM ton/yr
3. Blend renewable H₂ into gas pipelines; CO₂ reduction >50MM ton/yr



Power Generation – Largest Growth in Gas Market

- > “Decade of Uncertainty” defaults to gas
 - Combined Heat and Power
 - > Res/Com CHP
 - > Industrial CHP and Tri-gen
 - Large-scale renewable/gas integration options
 - > Gas simple- and combined cycle to stabilize intermittent wind and solar PV
 - > Solar/gas integrated cycles
 - Gas role in energy storage



Residential Appliances

Tokyo Gas/Panasonic Fuel Cell

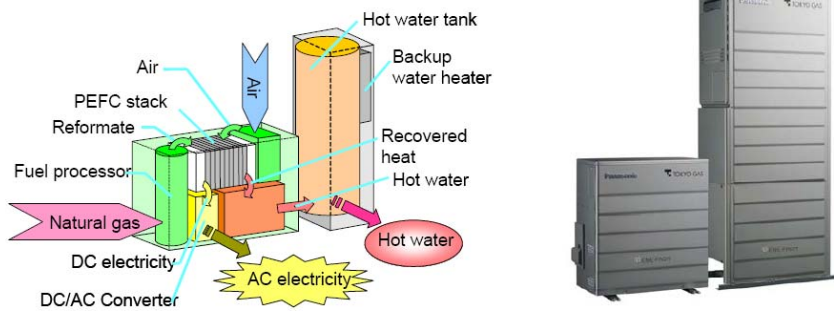


Figure 1: Schematic of system (Left) and Exterior of new model (Right)

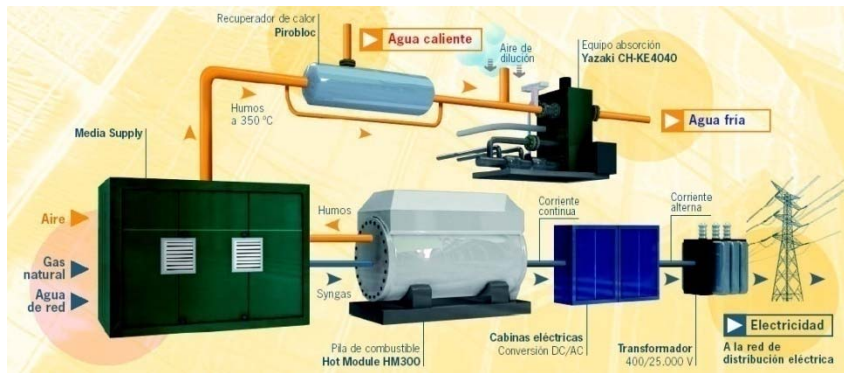
Geothermal Heat Pump



Commercial Hardware

Solar/Gas Chiller

MCFC Tri-gen system



Industrial Applications



High Efficiency Boilers With Exhaust Heat & Water Recovery



Waste Heat Chiller/Heater



CHP Systems



High-Temperature Solar Thermal for Steam Generation, Process Heat and Cooling

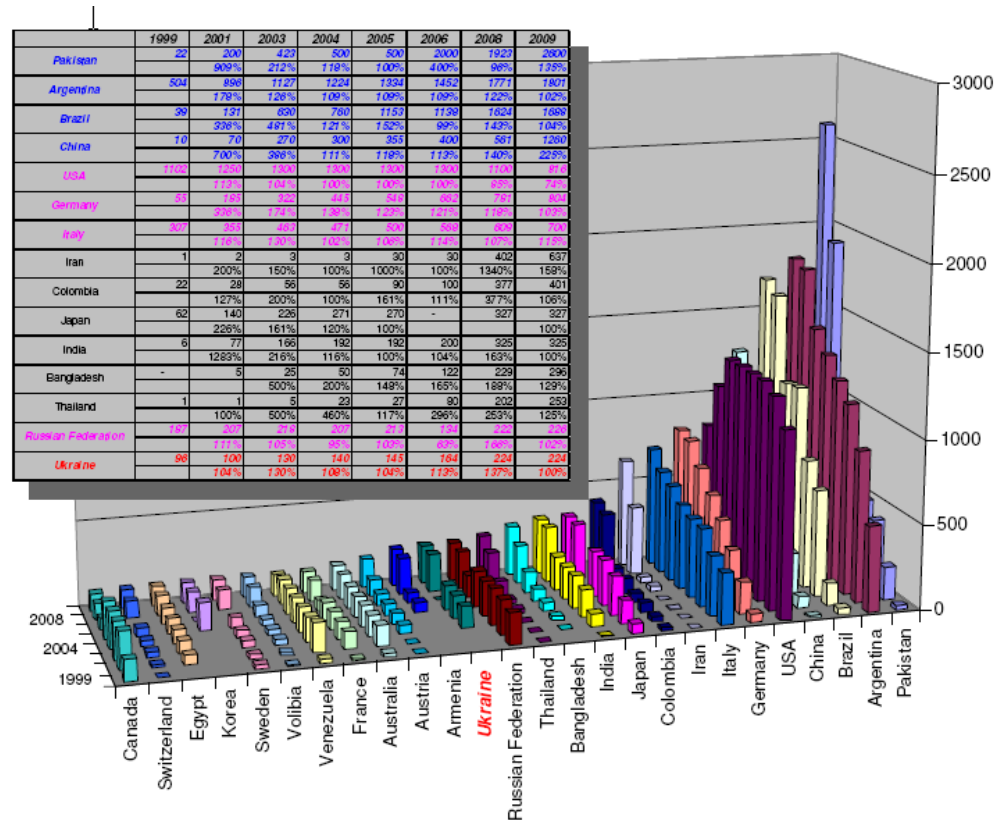
Transportation

> Drivers

- Transportation consumes 40% of US primary energy
- Energy security
- Oil/gas arbitrage

> Tax incentives renewed in '09

> Medium and heavy-duty fleet conversions



Renewables Becomes Gas

> Evolution from *adventitious* to *intentional*

- Manure, wastewater treatment, landfill
- Anerobic digestion of energy crops
- Biomass gasification to SNG

> Methane is the most efficient fuel product from biomass

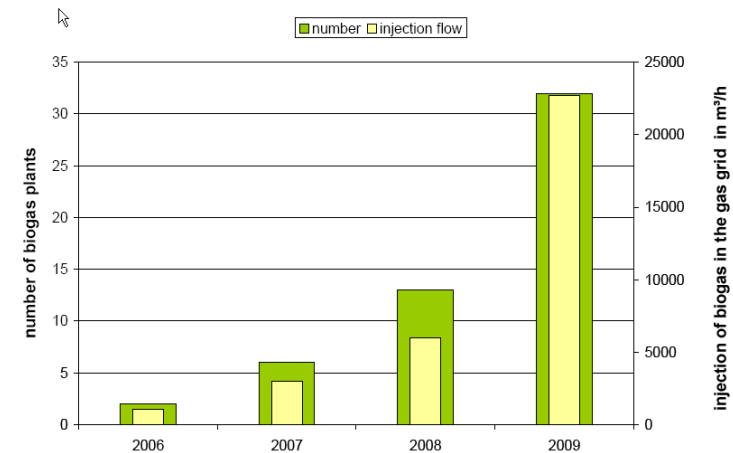


Fig. 3 Development of biogas injection in Germany [5]

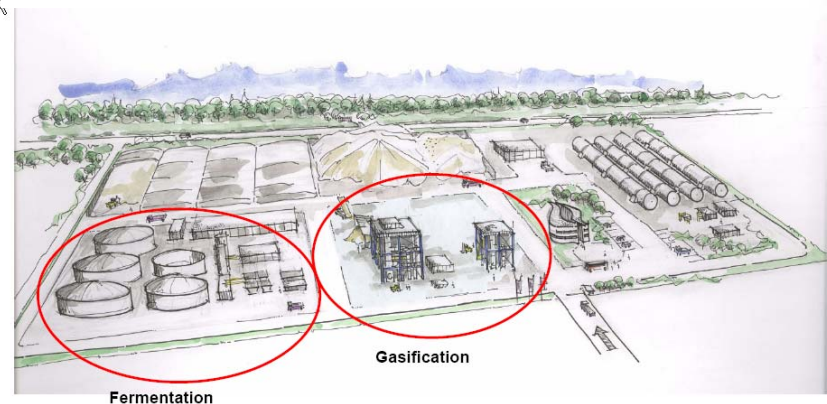
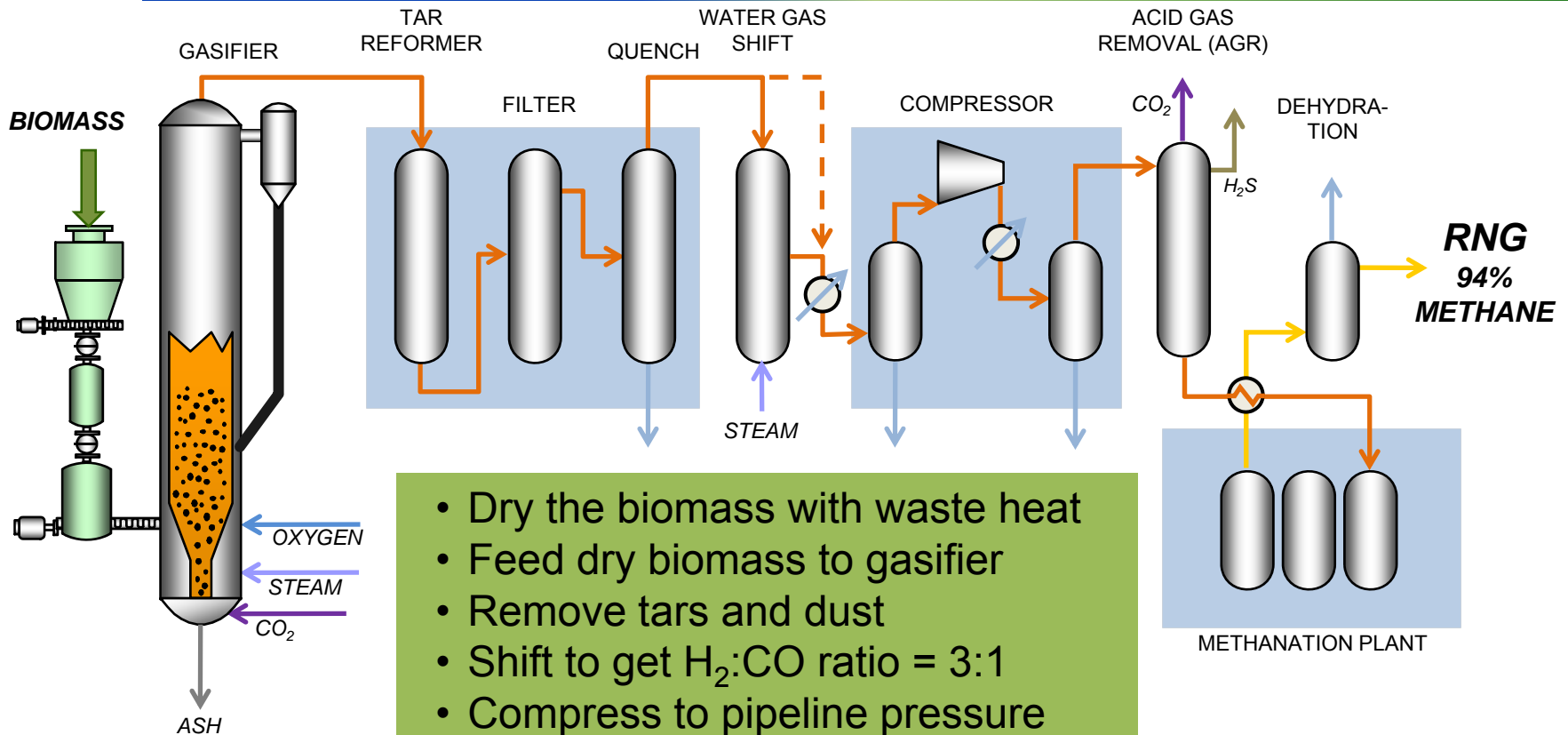


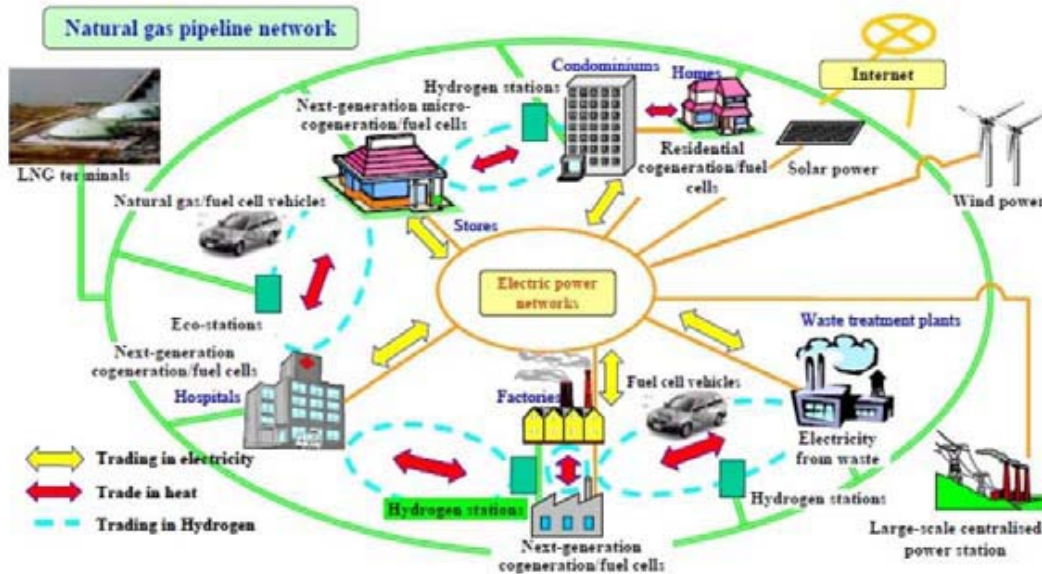
Fig. 5 Outline of the TBM complex in Geislingen (Germany) from [36]

The Renewable Natural Gas Process



- Dry the biomass with waste heat
- Feed dry biomass to gasifier
- Remove tars and dust
- Shift to get $H_2:CO$ ratio = 3:1
- Compress to pipeline pressure
- Remove acid gases including CO_2
- Convert syngas to 94% methane
- Remove remaining moisture

Smart Grid Changes the Game



- > Gas is Essential to Smart Grid objectives
 - Reliability
 - Carbon management
 - CAPEX and OPEX costs
- > Holistic Energy Grid
 - Customer choice
 - Electric, Gas, Renewables
- > Integrated automation gas operations
 - Wellhead-to-burner tip
 - Across energy grids
 - Real-time information

Closing Thoughts

- > Natural gas has been illuminating the future for two millennia
 - Abundant, clean, versatile
 - Significant potential to quickly and economically decarbonize the economy
 - Facilitates the expansion of renewable energy
 - Technical challenges are manageable, but require commitment
- > Policy, technology, and economics may benefit from better alignment
 - Holistic approaches
 - Life cycle analysis
 - Technology-neutral incentives