Hydrogen Energy Storage Policy Considerations

Hydrogen Storage Workshop

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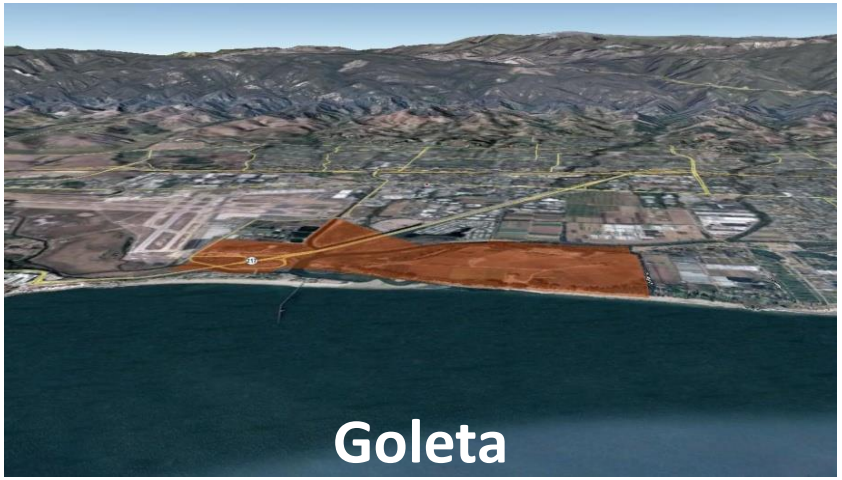
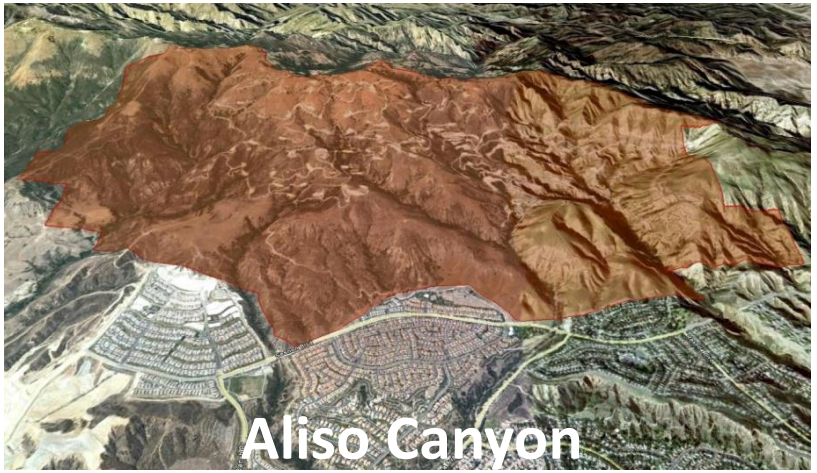
Methane is a Great Storage Medium

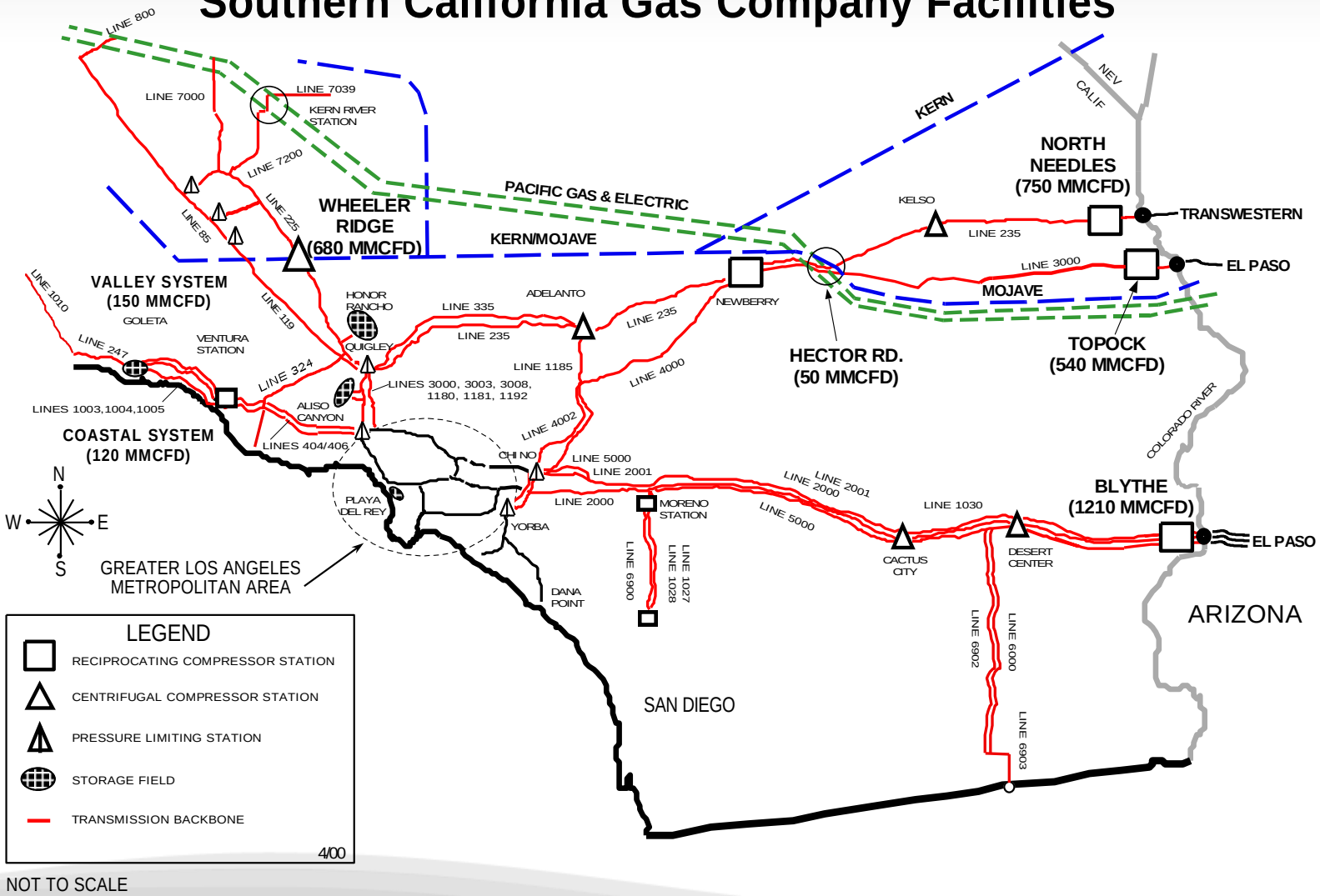
SoCalGas' storage fields are the largest energy storage resource in the region





And There's a Fully Built Delivery System

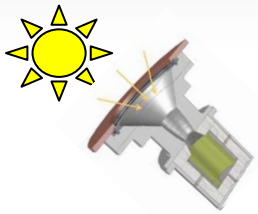
Southern California Gas Company Facilities

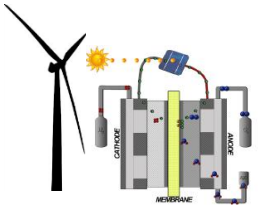


NOT TO SCALE

RNG Pipeline and Storage Pathways

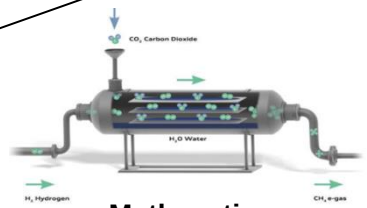
Solar Thermal Catalytic H2 Production
0.6% Energy Loss
TRL = 2





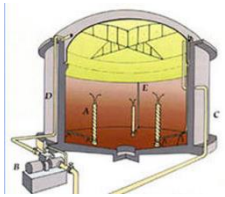
Renewable P2G H2 Production
33% Energy Loss
TRL = 9

Blending
TRL = 4



Methanation
20% Energy Loss
TRL = 7

Gasification
22% Energy Loss
TRL = 7



Anaerobic Digester
TRL = 9

CO2

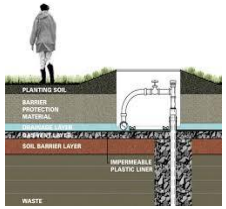
$CH4/CO_2$ Separation
Pressure Swing Adsorption
Amine Scrubbing
Water Scrubbing
Membrane
3% Energy Loss
TRL = 8

Compression, Odorization, Injection & Transport
.0.6% Energy Loss
TRL = 9

Dry / Woody

Wet

Organic Matter



Landfill Biogas Collection

WWTP Biogas Collection

Current cost range
$10 - $40/ MMBtu
+ transportation

“Dispatch” of Low-Carbon Gaseous Fuel Resources

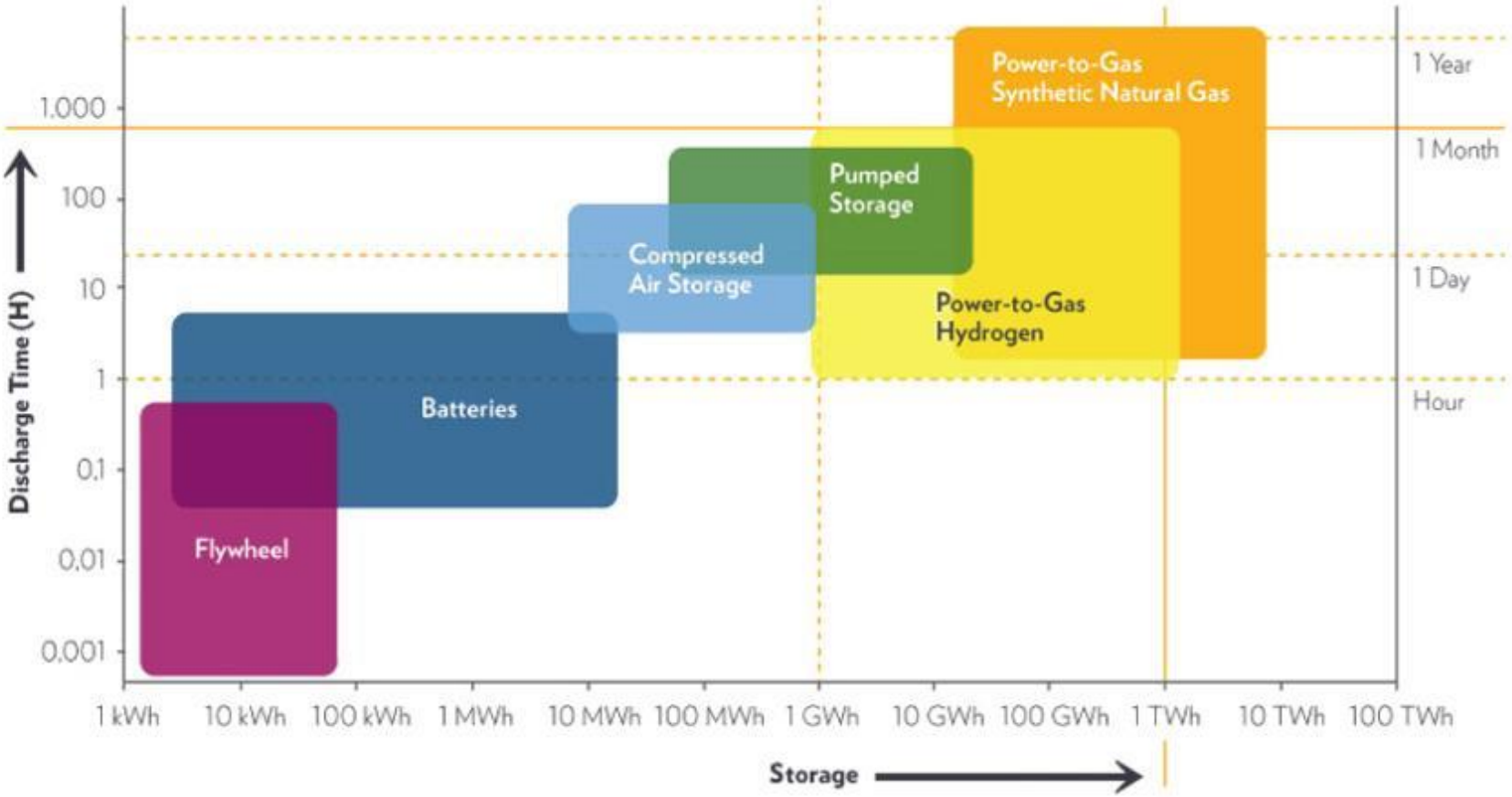
- Vehicle Fuel
- Generation / Storage
- End Use

Delivered Cost

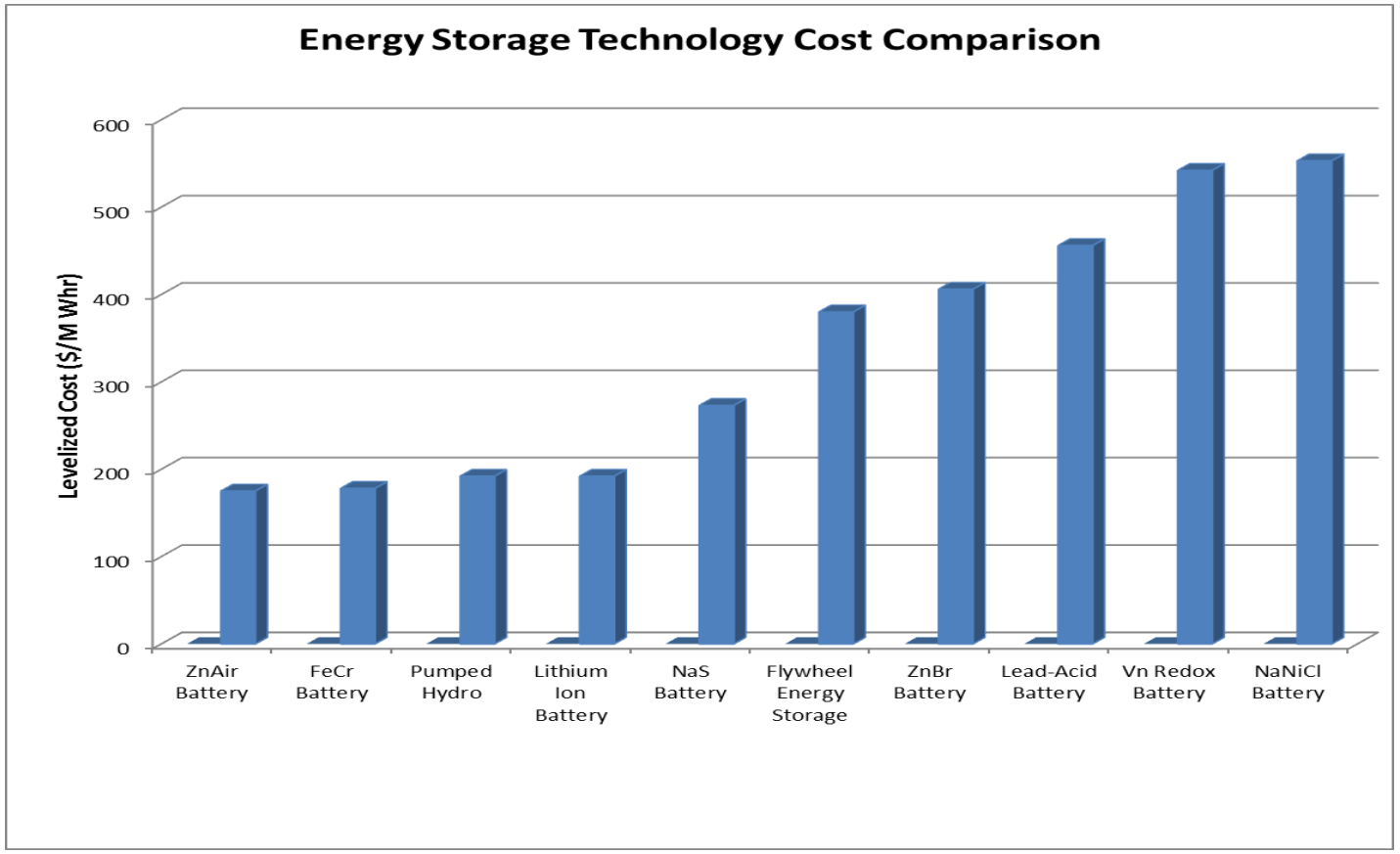
Mandates / Incentives

Consumer Preference

Gaseous fuels provide unique storage functionality



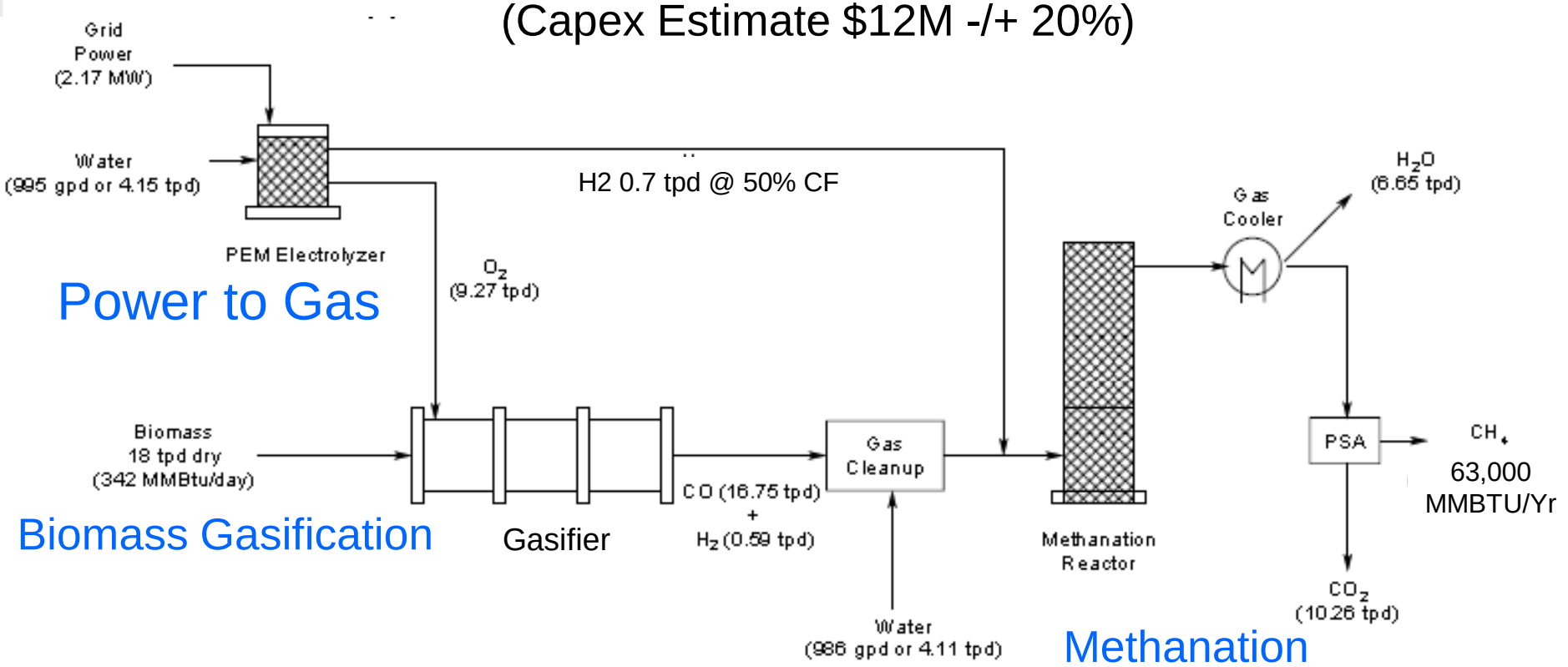
Energy Storage Costs



Sources: D. Steward, G. Saur, M. Penev, and T. Ramsden, "Lifecycle Cost Analysis of Hydrogen Versus Other Technologies for Electrical Energy Storage", NREL/TP-560-46719, November 2009
A. Akhil, G. Huff, A. Currier, B. Kaun, D. Rastler, S. Bingquing, A. Cotter, D. Bradshaw, W. Gauntlett, "DOE/EPRI 2013 Electricty Storage Handbook in Collaboration with NRECA", Sandia Report, SNAD2013-5131, July 2013

Power-to-Gas Demonstration Concept

Power-to-Gas Integrated with
Biomass Gasification/Methanation
(Capex Estimate $12M -/+ 20%)



Some Rough Arithmetic for Demo Cost Recovery

Revenue depends on market value of the product

- Storage = $0.20/kwh based on battery alternatives ~ $30/MMBTU
- RPS resource = ~$0.07 - 0.12/kwh (intermittent) ~ $12 -$20/MMBTU
- RCNG = $4/gallon provides ~$15/MMBTU for RNG to the pipe

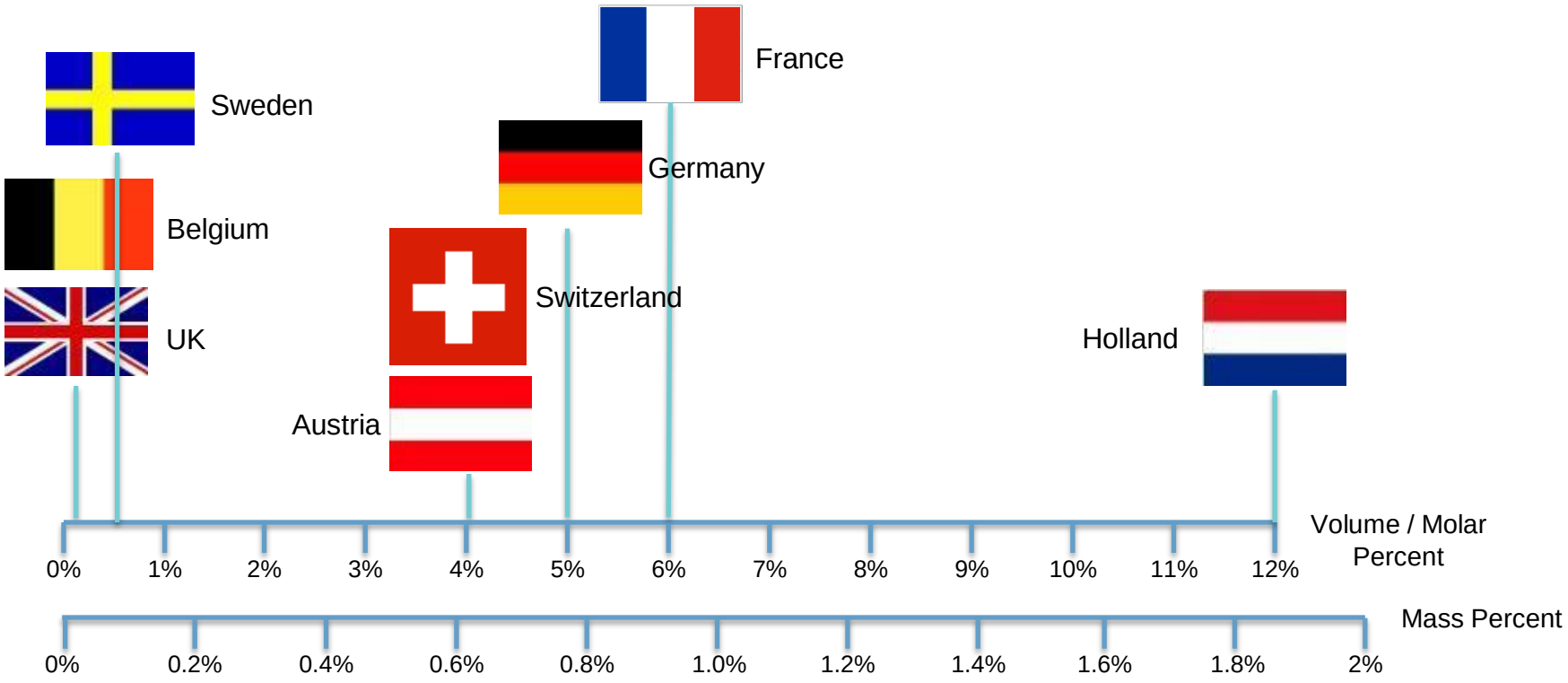
	SNG Revenue Contribution to Fixed Cost[1]	
	$10 / MMBTU	$15/MMBTU
Project Cost $10M	Simple Payback = 16 yrs Lending Capacity[2] = $5.6M	Simple Payback = 11 yrs Lending Capacity = $8.0M
Project Cost $15M	Simple Payback = 24 yrs Lending Capacity = $5.6M	Simple Payback = 16 yrs Lending Capacity = $8.4 M

[1] Revenue available to cover fixed cost net of variable production costs.
[2] Coverage Ratio of 1.4 after tax @ 3.75% (DoE Loan Guarantee) (max 80% D/E)

Policy Considerations

- Storage Definitions
  - CA PU Code broad and incorporates virtually all types of storage
  - Procurement mandate is technology neutral but valuation of different use cases tbd
  - Withdrawal and injection of electricity at different locations could pose an issue
- Bookkeeping for renewable attribute (input power, feedstock) is not fully defined for P2G and for non-biogas pathways
- NEPA/CEQA review
- Incentives / funding eligibility for multi-purpose facilities (transportation fuel, power generation, power storage, other grid services…) – securing revenue streams to support project finance
- H2 concentration limits specified in gas quality standards

European Union H2 Blending Limits



Source: ITM Power

SoCalGas Biogas Standards Development

2007 -- Initiated evaluation and analysis

2009 -- Issued biogas conditioning guidance document for biogas feedstocks other than landfill gas (health concerns)

2010 – Initiated GTI study of landfill gas constituents

2012 -- Assembly Bill 1900 directs public utility commission to institute a rulemaking for landfill gas

2014 – Commission decision issued on landfill gas monitoring and control requirements and removes prohibition