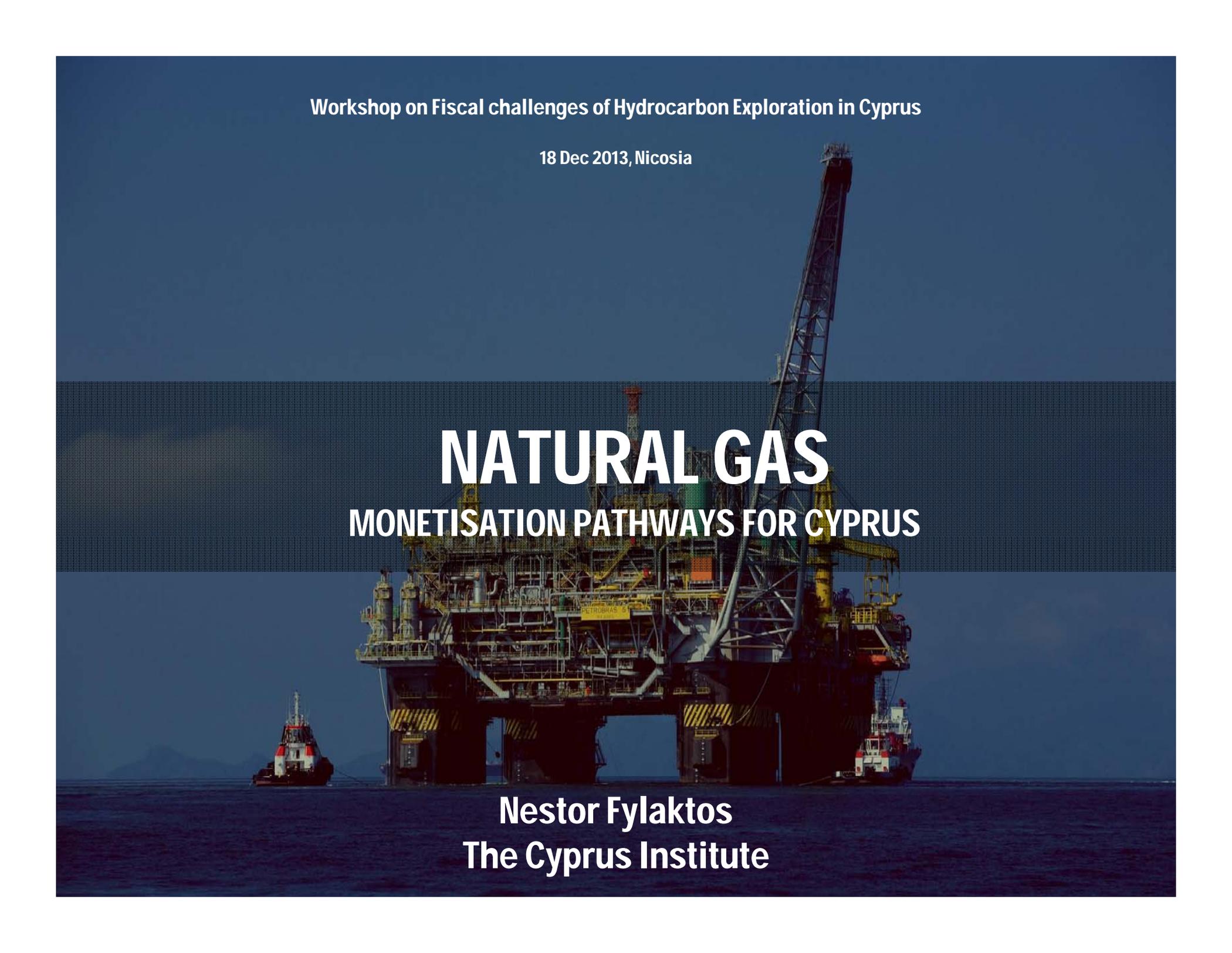


Workshop on Fiscal challenges of Hydrocarbon Exploration in Cyprus

18 Dec 2013, Nicosia

A large offshore oil rig is the central focus, situated in the middle of the sea. The rig is a complex of steel structures, including a tall derrick and various platforms. Two smaller support vessels are visible on either side of the rig. The background shows a clear blue sky and a calm sea. The text is overlaid on a semi-transparent dark blue band across the middle of the image.

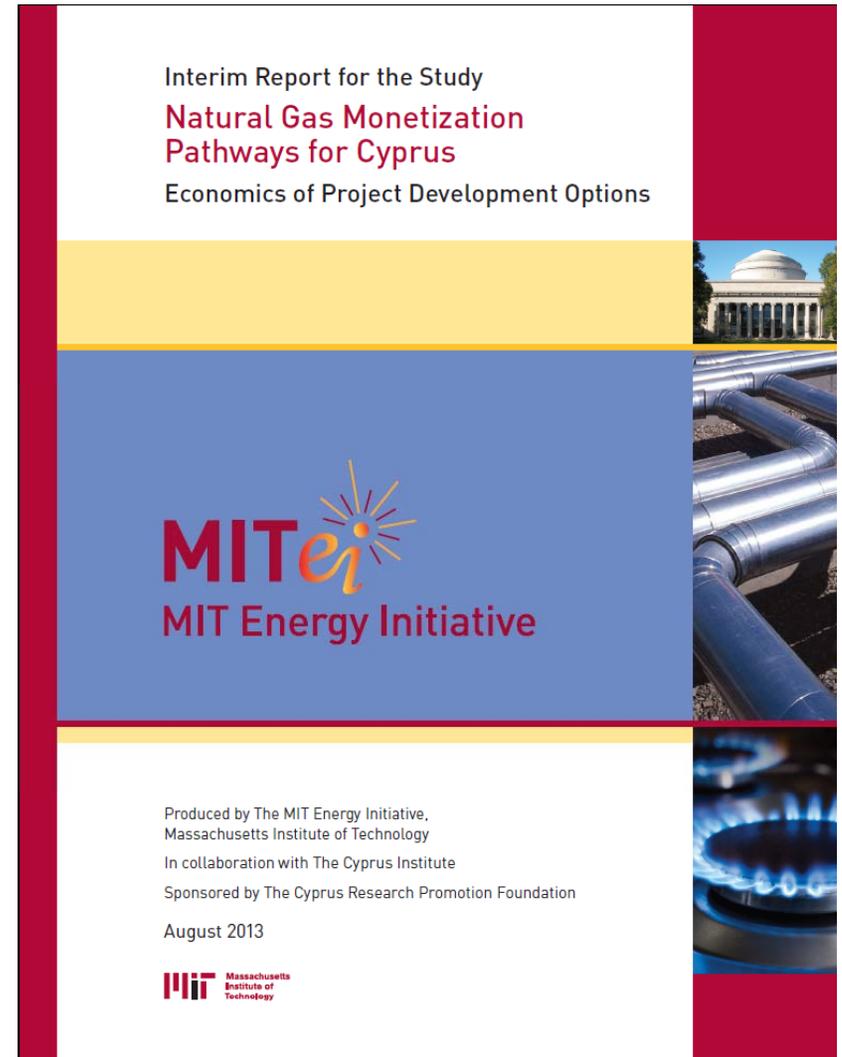
NATURAL GAS

MONETISATION PATHWAYS FOR CYPRUS

Nestor Fylaktos
The Cyprus Institute

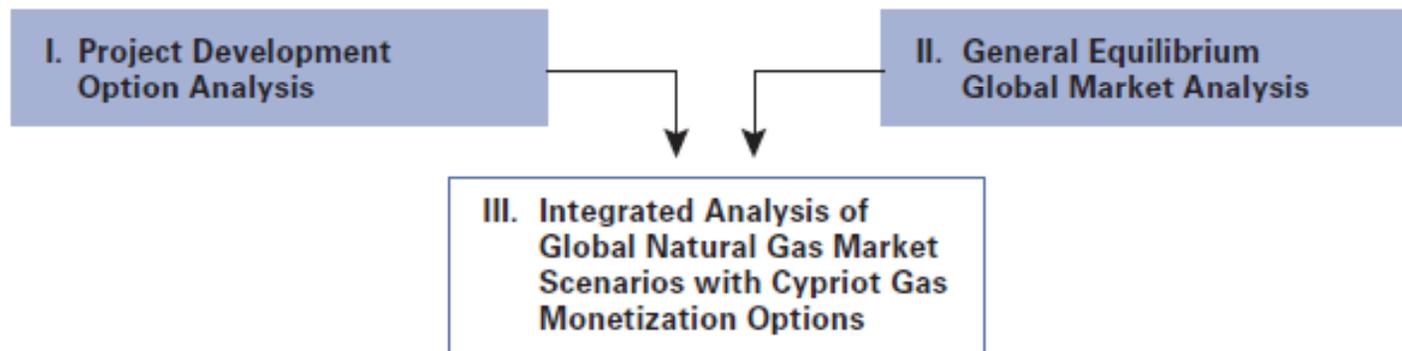
The MIT-Cyl Study

- Study was commissioned in August 2012, practically started Jan 2013
- Tail-end of a larger MIT-Cyl agreement
- Original PI was Ernest J. Moniz
- Collaboration between the MIT Energy Initiative (MITei) and the EEWRC at the Cyprus Institute, funded by RPF
- Has produced two interim reports, final in Aug 2014
- 2nd interim report accessible at Cyl website



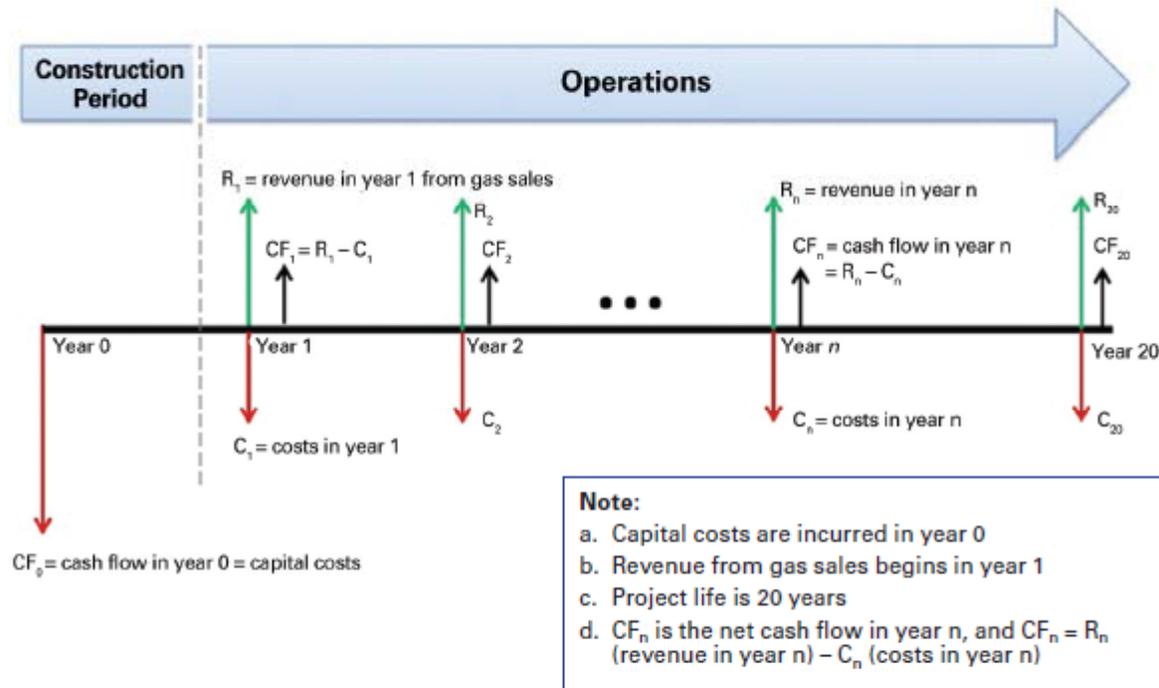
Study structure

- 1st stage: Supply-side focus
- ‘Apples-to-apples’ DCF model
- Use of open access information
- Focus on economics
- Captures broad factors
- 2nd stage: Regional and global markets



DCF economics

- All assessments on Break-Even-Price (BEP)
- Gas price needed to ensure NPV of project is zero
- For realisable prices over BEP, project is worth pursuing
- Otherwise it should not be undertaken



Gas discoveries in Cyprus



Map of Levantine Basin (that includes the Aphrodite Field)

Early reserve quantification of Aphrodite discovery

Tcf of gas

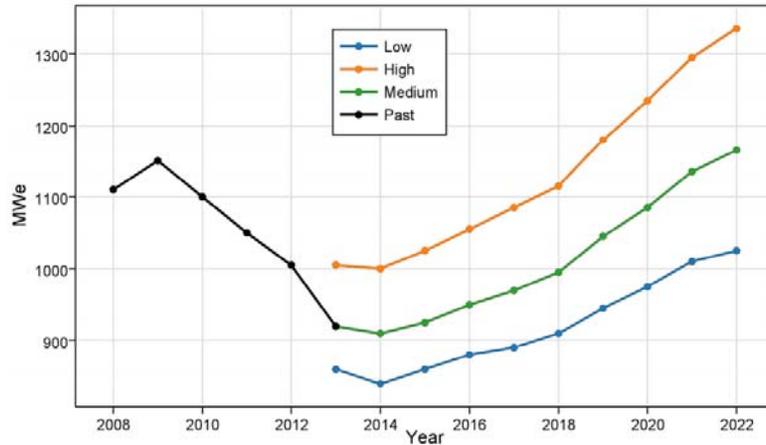
	P75	P50	P25
Noble '13	3.6	5.0	6.0
NS&A '13	4.1	-	-
NS&A '11	-	5.1	-
Noble '11	5.0	7.0	8.0

USGS assessment of technically recoverable gas resources in the Levantine basin

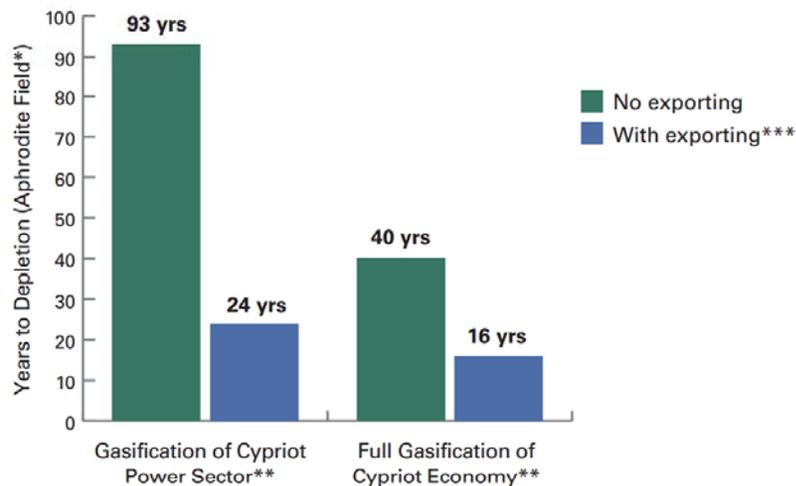
Tcf of gas

	Mean	P95	P50	P5
Margin AU	5.1	1.7	4.6	10.6
Sub-salt AU	80.8	32.5	74.2	150.6
Plio-Pleist. AU	34.4	15.4	32.0	61.6
Total	122.4	50.0	112.6	227.4

Domestic Flows



Source: EAC. 2013



* Assumes mean estimate of Aphrodite Field (7tcf)

** Based on 2012 energy consumption with 1.5% annual growth

*** Assumes 250bcf/yr export throughout (equivalent to single-train LNG plant)

- Power sector gasification partially under way
- Cyprus plans to gasify domestic & industrial sectors
- Infrastructure not here yet to take advantage of finds - gearing towards exports

Monetisation pathways

- Finds might be small in a global context, but huge for a country the size of Cyprus
- Monetisation will require either liquefaction (LNG), pipeline construction or some other option (GTL, GTC, CNG, GtW etc.)
- Major emphasis placed on LNG
- Other options will be brought to the same standard

LNG – The main focus

Pipeline options

GTL, GTC & CNG options



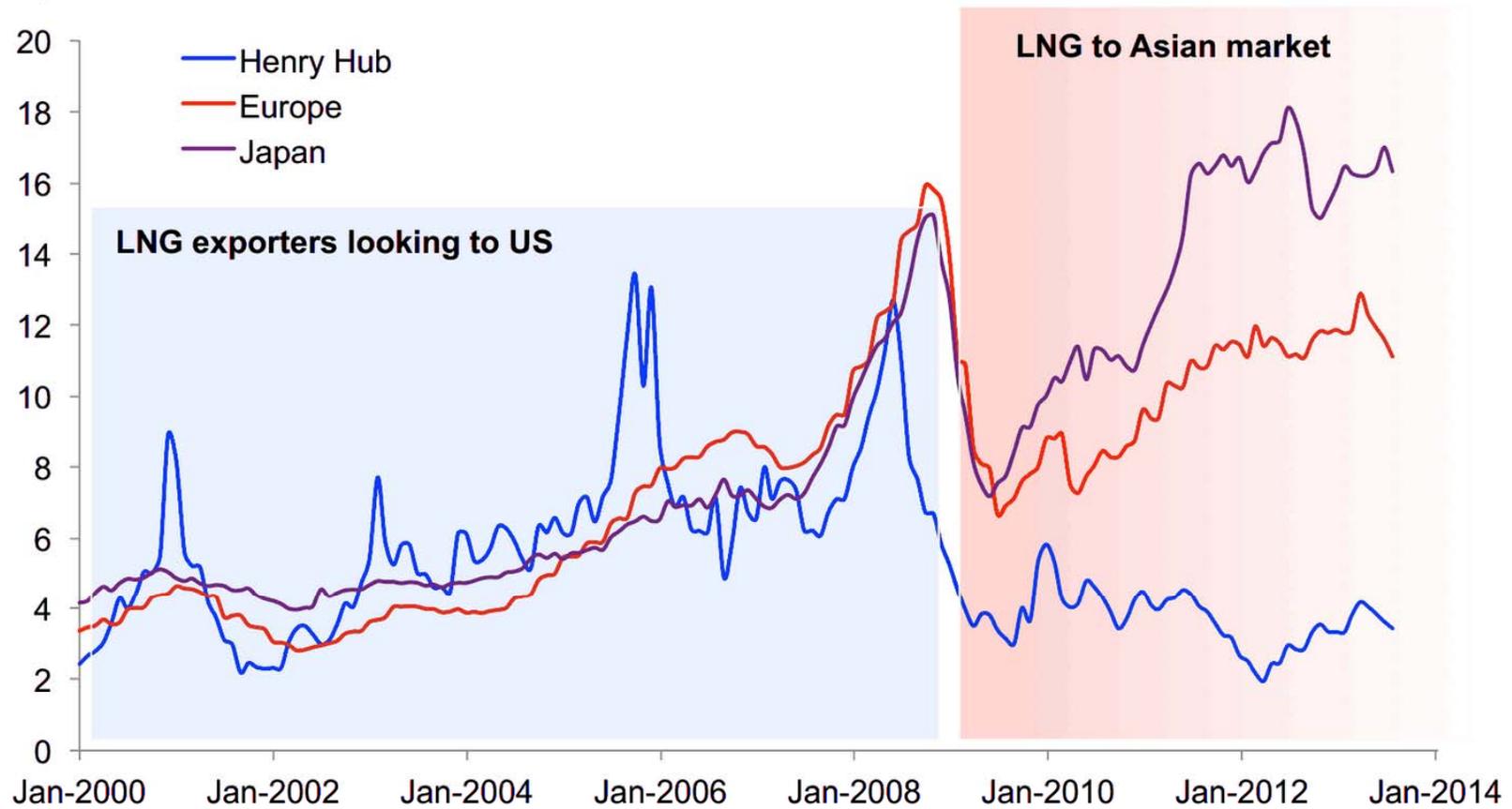
Some advantages of LNG in the Cypriot context

- Provides access to both the Atlantic and Pacific Basin natural gas market
- Considerably reduces exposure to geopolitical risk
- Likely the fastest path to monetization
- Contemporary scale well matched to size current discovery
- Expansion possible with the potential for enhanced “brownfield” economics

LNG global market outlook

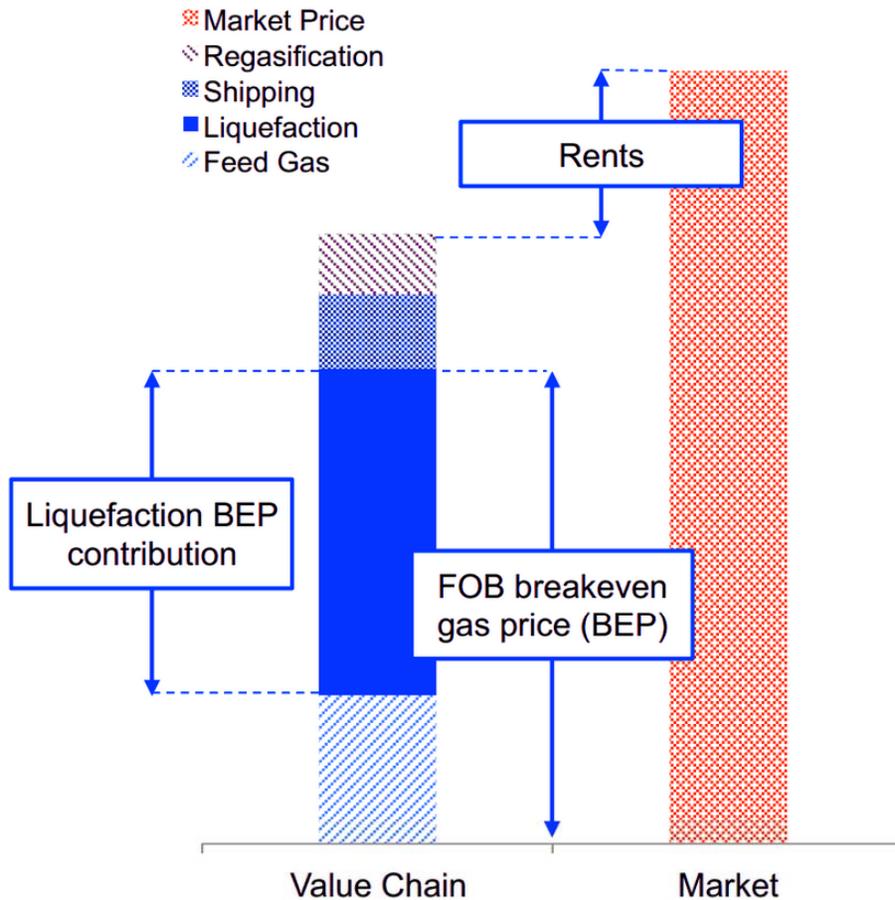
Variation in natural gas spot pricing in major global markets since 2000

\$/MMBtu

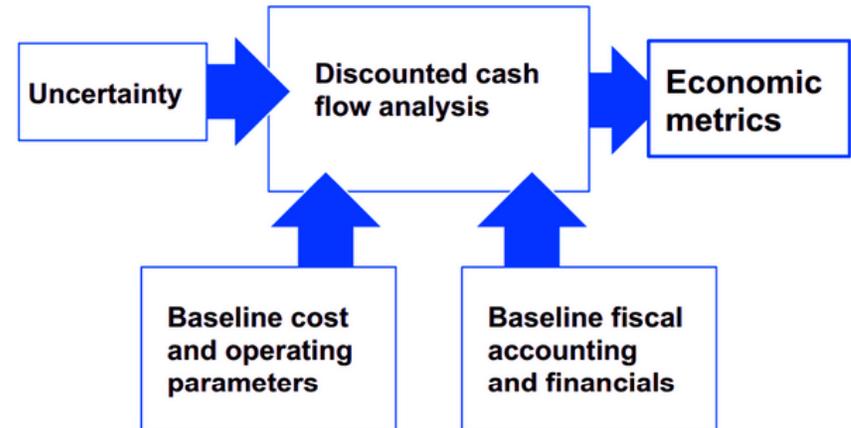


DCF and Liquefaction

Illustration of liquefaction contribution to Natural Gas BEP



Structure of the economic analysis of the liquefaction option



Baseline assumptions - and sensitivities

Baseline project parameters

- Capital costs
- Operating costs
- Utilization rates
- Assumes plant lifetime
- Feed gas costs

Fiscal, accounting & financial parameters

- Tax regimes
- Depreciation schedules
- Utilization rates
- Capital structures
- Cost of capital

Uncertainty

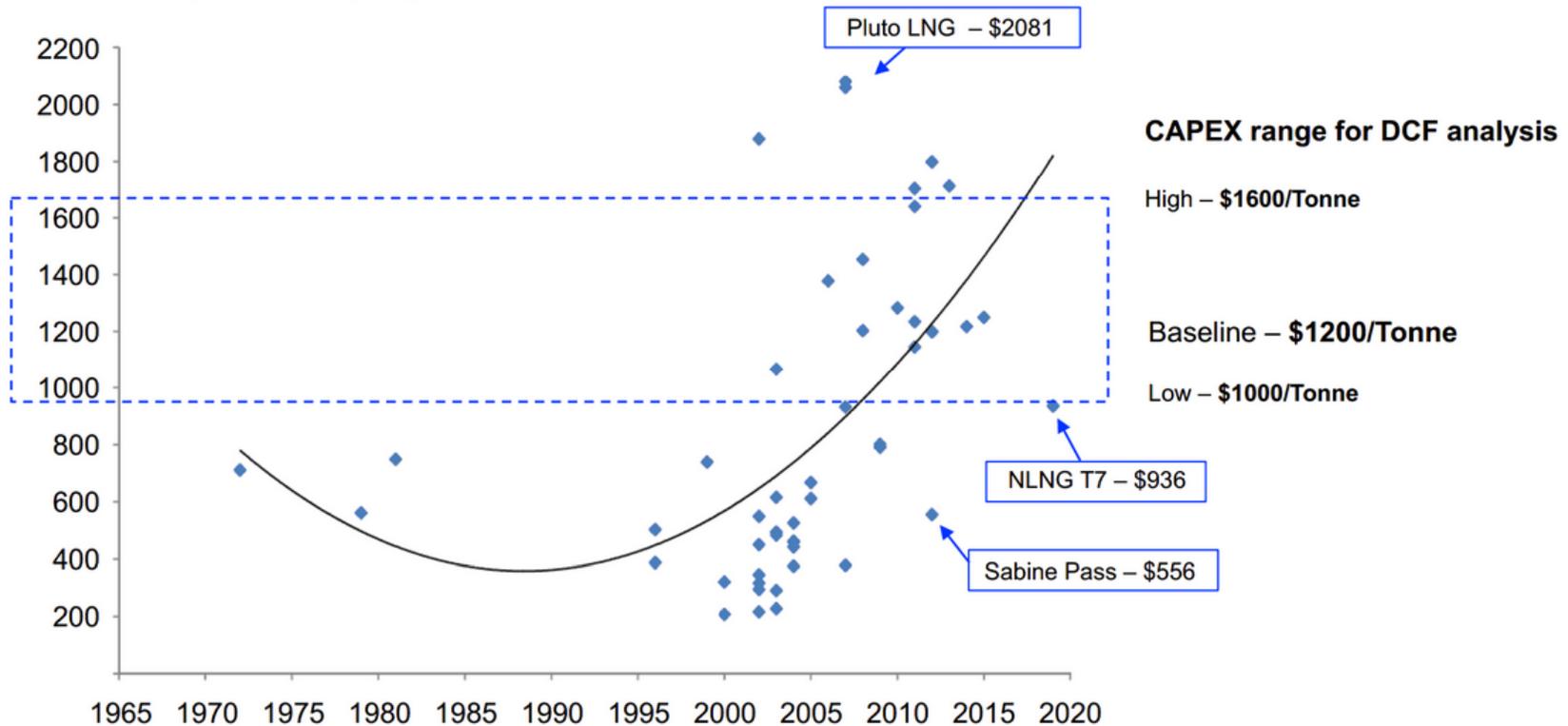
- CAPEX
- Feed gas costs
- Plant utilization
- Project delivery timing
- Fiscal regime
- Etc.

Major project parameters

	Baseline	Low	High
Plant CAPEX – \$/Tonne of Capacity	1,200	1,000	1,600
Feed gas cost – \$/MMBtu	2.5	2.0	4.0
Plant utilization rate – %	85	75	95

LNG is extremely capital intensive

Illustration of LNG liquefaction plant cost inflation
\$/Tonne of liquefaction capacity



Utilization is critical

Illustration of liquefaction contribution to Natural Gas BEP
Million tonnes of LNG

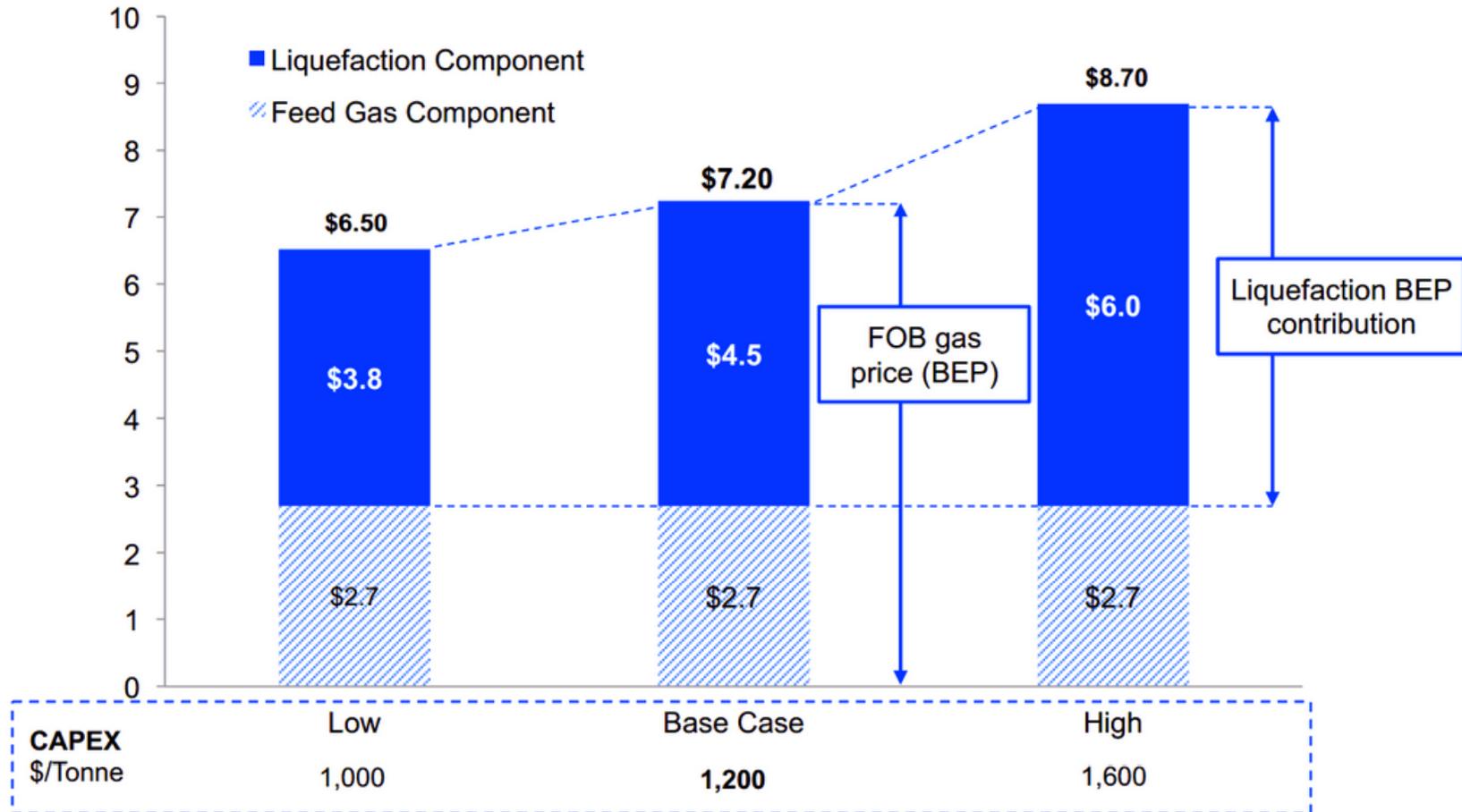


- Global average is 87% due to recent strong demand, but variations are large
- Strong growth in capacity may change this
- Growing spot markets for LNG could absorb supply, but at what price?

FOB Breakeven Price - Fixed Feed Gas

Assessment of liquefaction plant economics and the impact of CAPEX variability

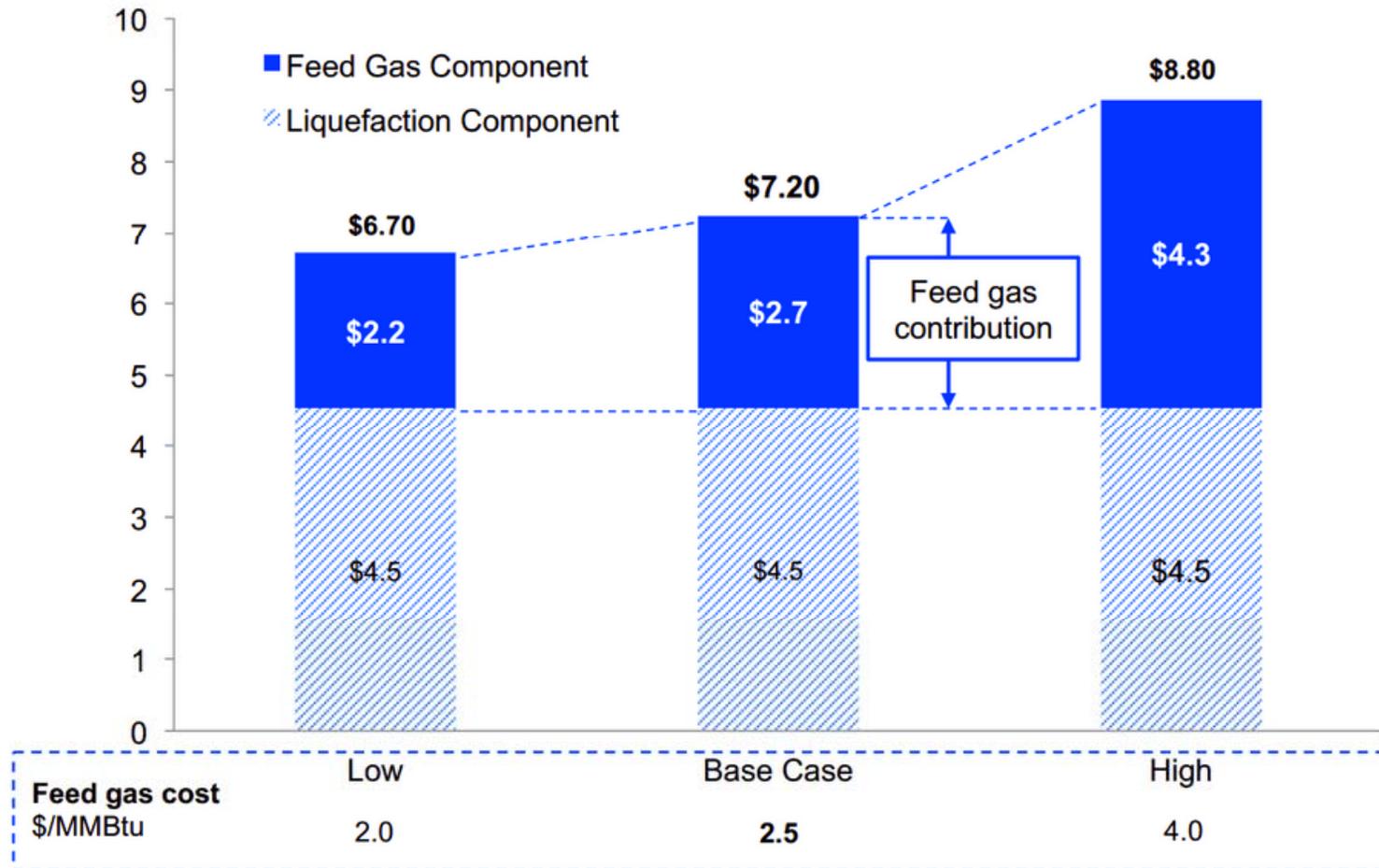
FOB Breakeven Price - \$/MMBTU



FOB Breakeven Price - Fixed Liquefaction

Assessment of Feed Gas price variability on plant economics

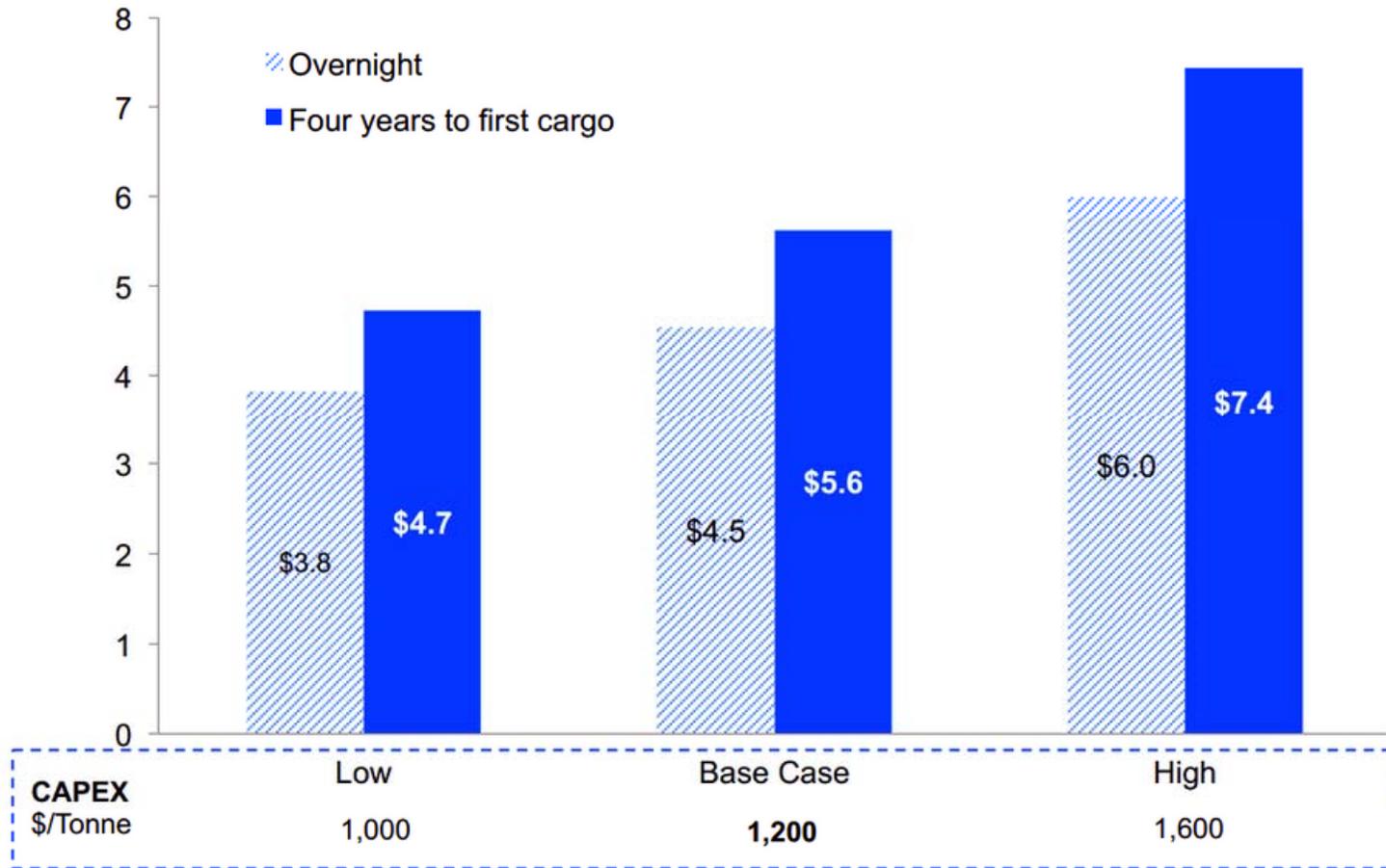
FOB Breakeven Price - \$/MMBTU



FOB Breakeven Price - Construction Timing

Illustration of how construction timing impacts liquefaction-only economics

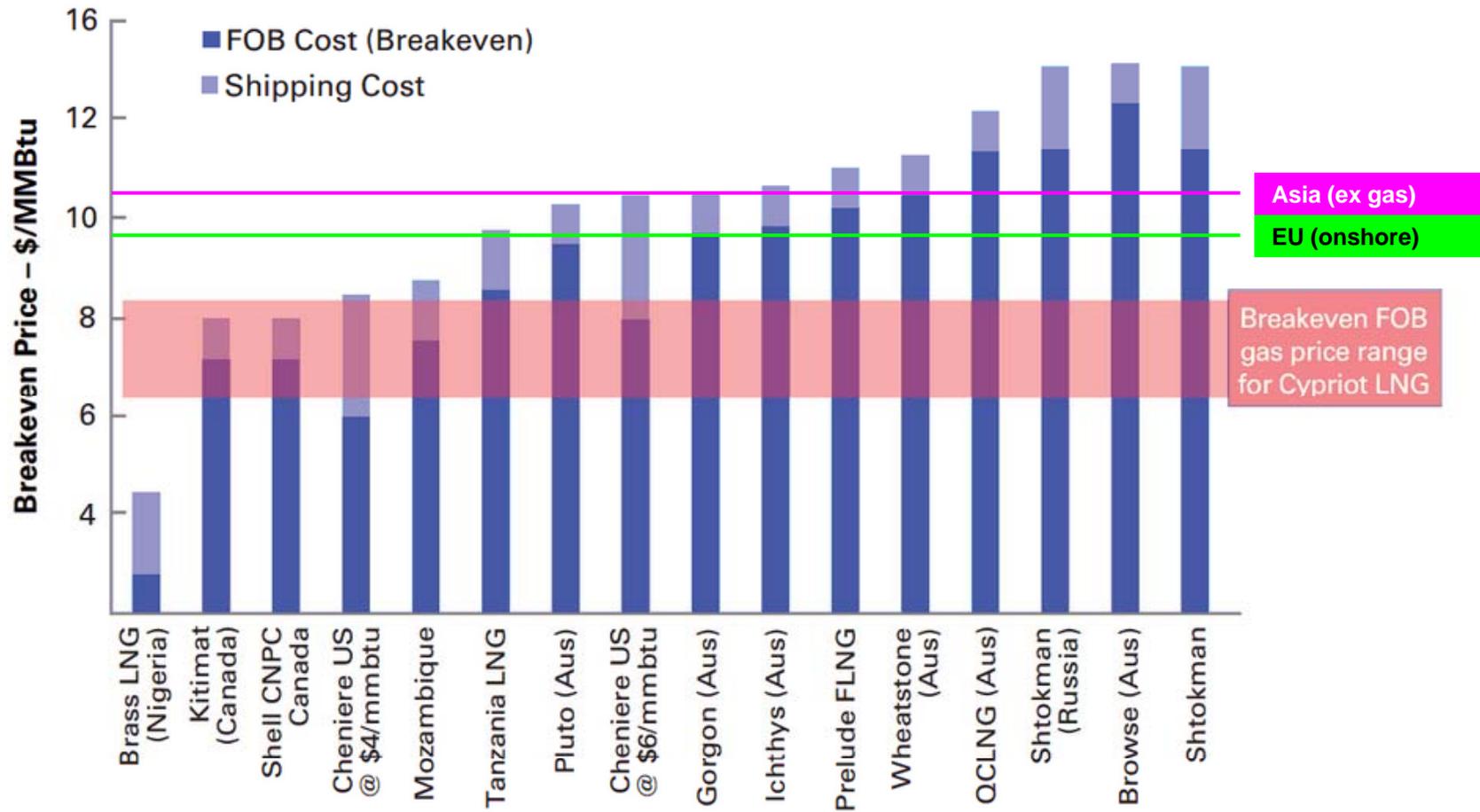
Liquefaction Breakeven Price - \$/MMBTU



Asian market LNG supply

Estimated breakeven costs for set of major contemporary LNG projects

Breakeven Price - \$/MMBTU



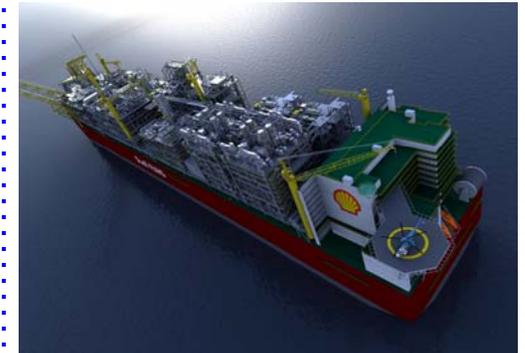
FLNG

- Reduced quantities in Aphrodite render the onshore LNG untenable
- A solution would be *in situ* liquefaction on board an FLNG vessel
- Alliances with regional discoveries (esp. Israel's) could make this option viable
- Security concerns are, however, a consideration

LNG - Main focus

Pipeline options

GTL, GTC, CNG, GtW



A Floating LNG vessel:

- Does away with the pipeline to Vassiliko
- Much smaller environmental footprint
- Same benefits as LNG – access to global markets

But:

- Expensive with current finds
- Technology still immature – none completed yet
- Employment benefits probably even less than those for a conventional LNG

A word on Gas contracting

Early years

- Long term contracts needed to finance both pipeline and LNG projects
- Small markets meant that spot selling was not an option
- Sharing of risk - buyer the volume risk, seller the price risk
- No gas-on-gas indicator to base pricing on

Today

- Projects involve large capital outlays, so still some risk mitigation is required
- LNG projects are built with a larger degree of self-contracting
- Supplier risk is higher, but allows for flexibility in the market
- Pipelines do not have (by definition) destination flexibility, but can take part in spot trade where available

Categorisation of global gas pricing mechanisms

- **Gas-on-gas competition** - Gas is priced in an open market setting, e.g. US (Henry Hub) and the UK (NBP)
- **Substitute energy prices indexation** - pricing usually linked to oil products, even though limited amount of competition exists. Situation in continental Europe and SE Asia
- **Oil indexation** - Contracts explicitly linked to oil via a special formula. Typical in Japan.
- **Bilateral monopoly contracting** - Bilateral agreements on gas price, often state controlled and mandated. Russia, China, Middle East.

Pipeline considerations

- Option for pipelines to Greece (via Crete) and Turkey were considered
- The Cyprus-Turkey pipeline is **not** considered feasible due to geopolitical constraints
- The technoeconomic analysis however is within the scope of the study

LNG - Main focus

Pipeline options

GTL, GTC, CNG, GtW



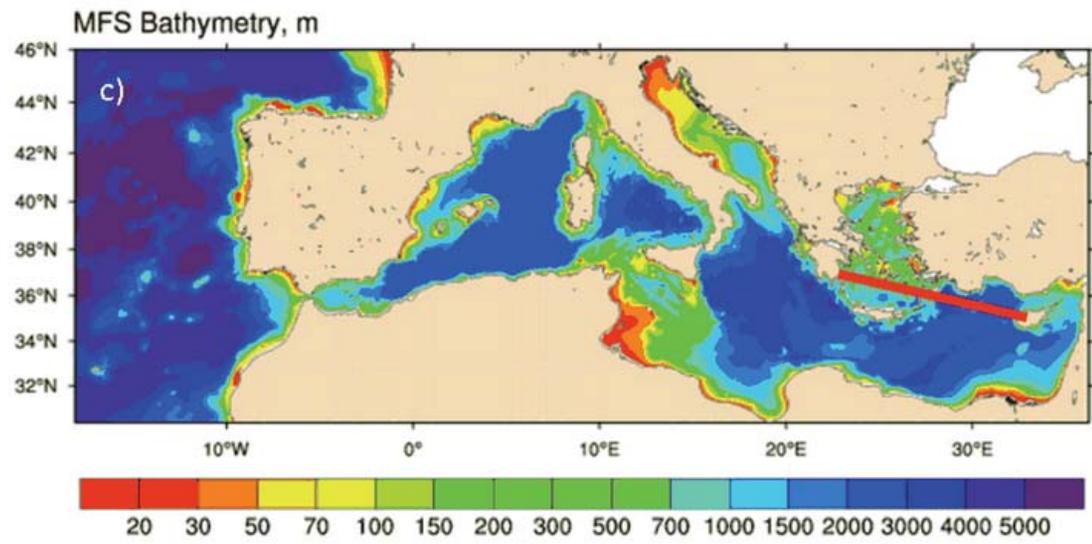
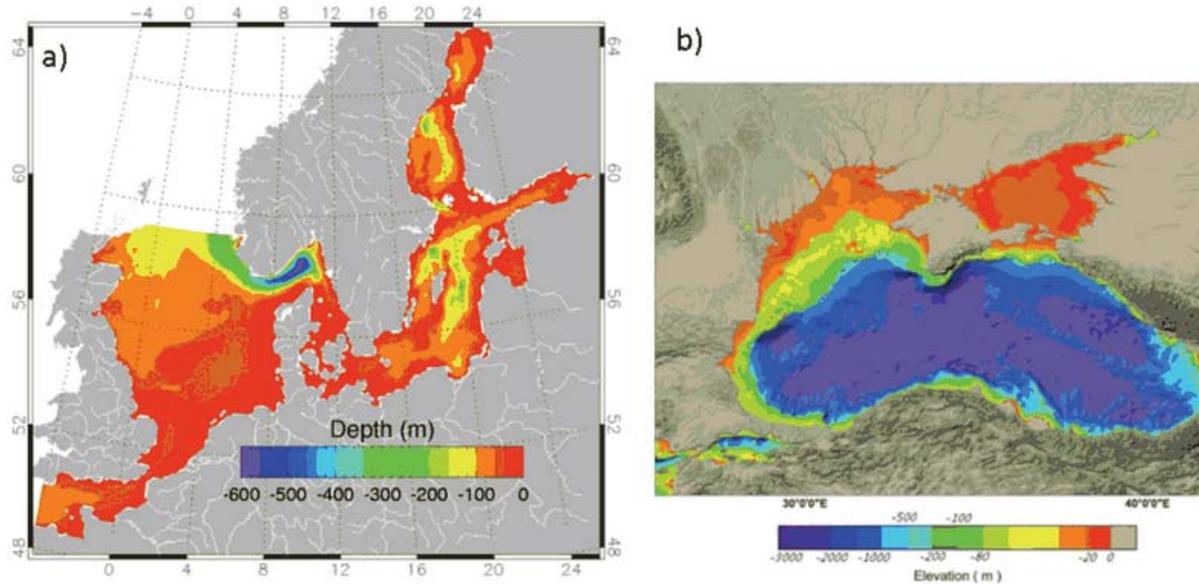
A pipeline (sub-sea) is:

- Cheaper for small distances
- Proven technology

But:

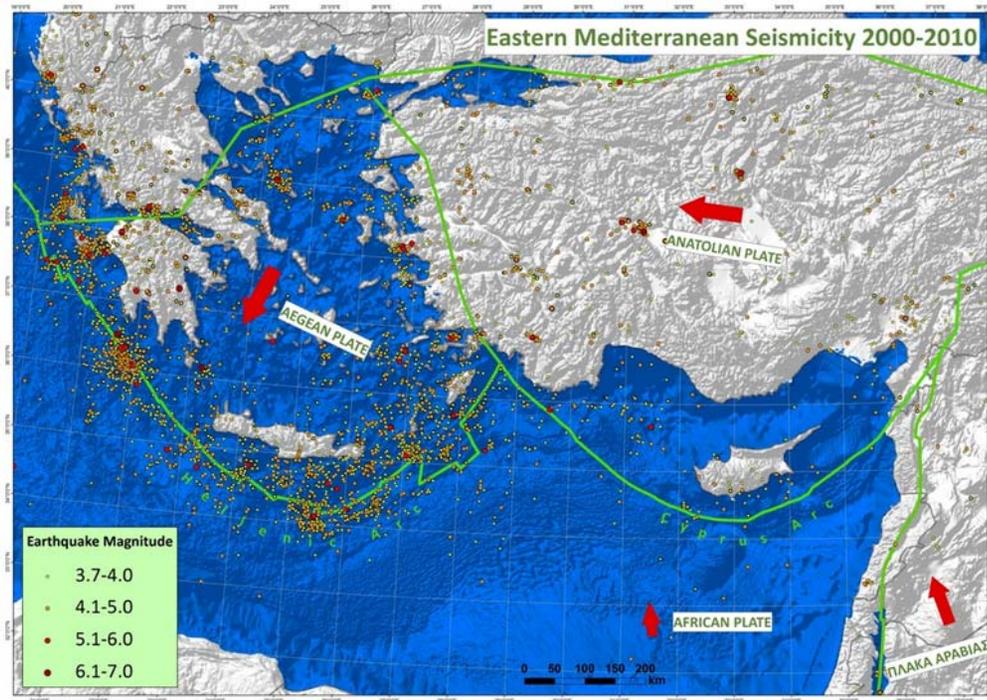
- Does not provide destination flexibility
- Ties exports to markets with uncertain profit potential

Pipeline to Greece is an engineering challenge



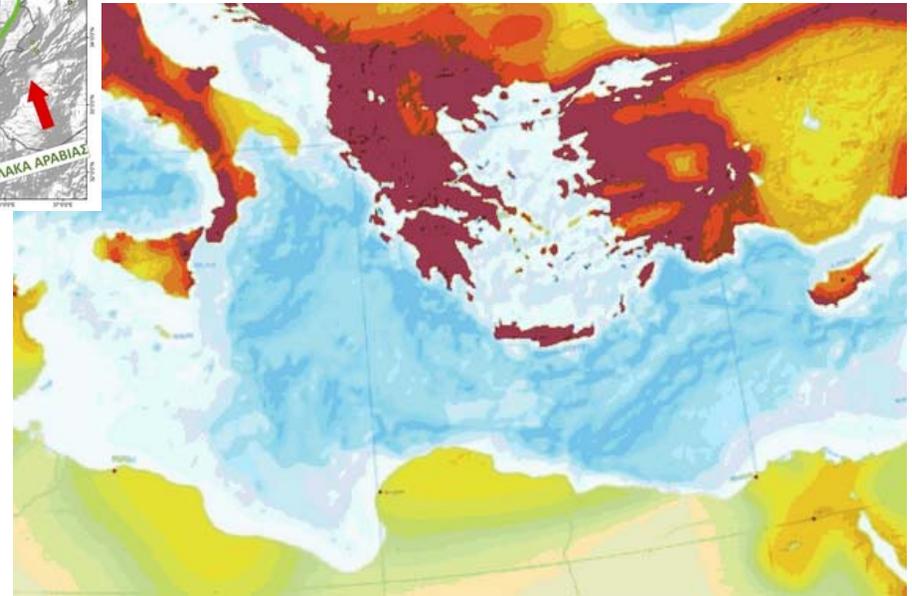
Source: DMI (2012), INGV (2009)

Seismicity



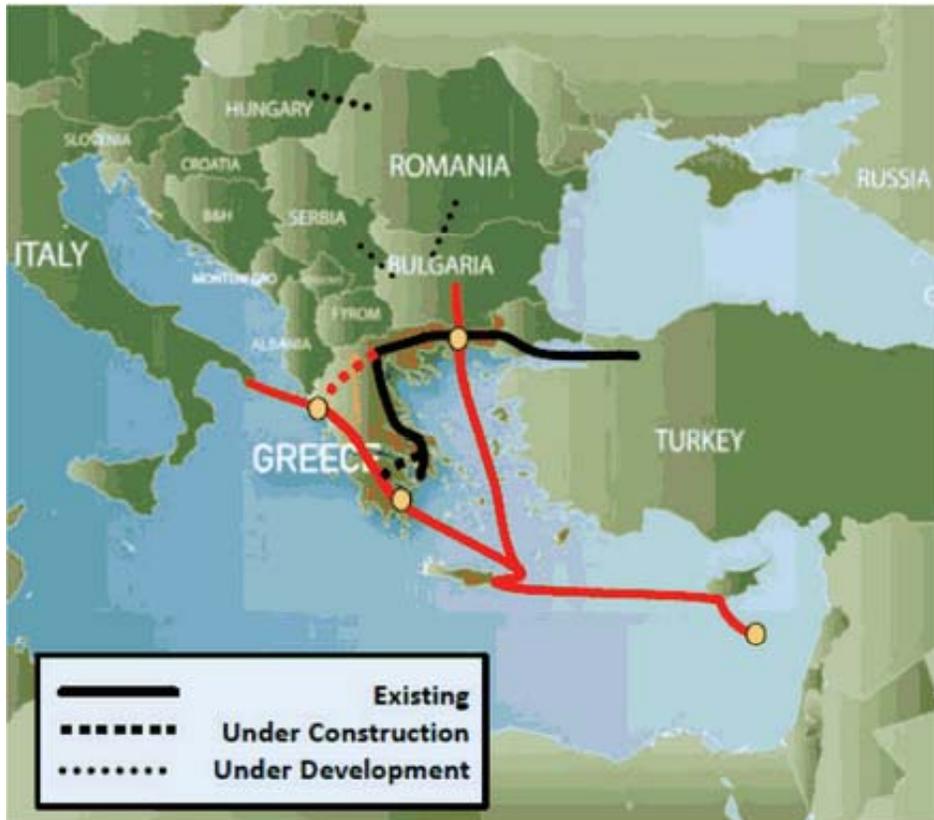
Source: Cyprus Geological Survey Dept.

- Project will straddle 2 different tectonic plates, 2 fault lines
- Area of increased seismic activity
- Seismicity complicates project and increases costs



Source: Jimenez et al. (2003)

Pipeline to Greece

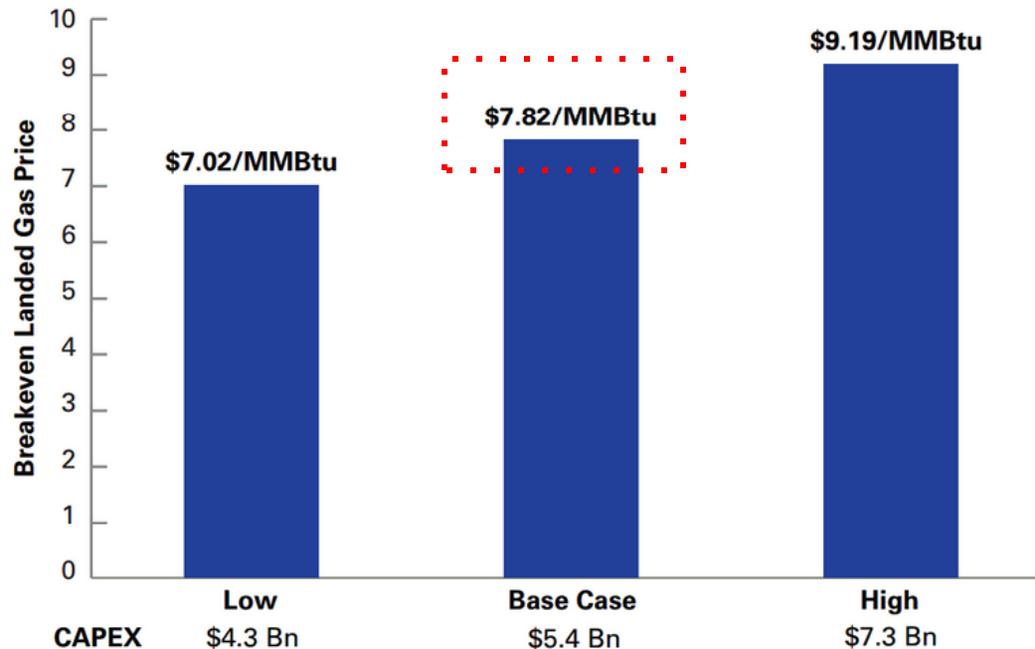


- A pipeline will most probably be built - the Aphrodite-Vassiliko connection
- Confirmed discoveries not enough for *both* pipeline and LNG
- Pipeline would reach Crete and then possibly split in two parts: One to the mainland and one to the North (DEPA, 2012)
- Costs are calculated for landing in Greece and transported to central Europe

Pipeline break even price for Greece

Sensitivity analysis of the breakeven price of a pipeline to Greece to CAPEX variability

Liquefaction Breakeven Price - \$/MMBTU



- **Landed price in Greece is \$7.82/MMBTU (2011 \$)**
- In Austria it's \$10.32/MMBTU
- Difference due to overground transportation costs

Compressed Natural Gas

- CNG is essentially a 'floating pipeline'
- Capacity set at 110 bcf/year
- Breakeven **landed** price is \$5.68/MMBTU
- Source of data is industry - no prior experience
- Final price might be biased due to uncertain input

LNG - Main focus

Pipeline options

GTL, GTC, CNG, GtW



A CNG shuttle service:

- Consists of a fleet that carry CNG to regional market
- Compression can be done offshore
- Only decompression facility required - no regasification

But:

- Compression ratio lower - half that of LNG
- Economics work for markets in close proximity only
- **Not** built commercially anywhere - financing risk is considerable

Move to higher resolution data

- **Feed gas**
 - Higher resolution assessment of the cost
 - Composition details regarding its content in higher-order hydrocarbons (liquids)
- **Fiscal structures and instruments**
 - Details of royalty instruments in Cyprus
 - Tax levels and accounting norms
- **Project partnering and contracting**
 - Details on corporate structures of gas development and export
 - Details on gas sales and contracting structures
- **Project timelines**
 - Field development and LNG facility construction

Gas to Chemicals (GTC-GTL)

- Gas needs to be piped onshore
- CH₄ to Syngas - or straight to methanol
- Process augmented by the presence of higher-order hydrocarbons (liquids) in the reserve
- Industrial use, or straight consumption of derivatives (usually in transport)
- Cypriot gas composition not clear - indications that it is 'dry', although some condensates were found (Dec 2013)

LNG - Main focus

Pipeline options

GTL, GTC, CNG, GtW

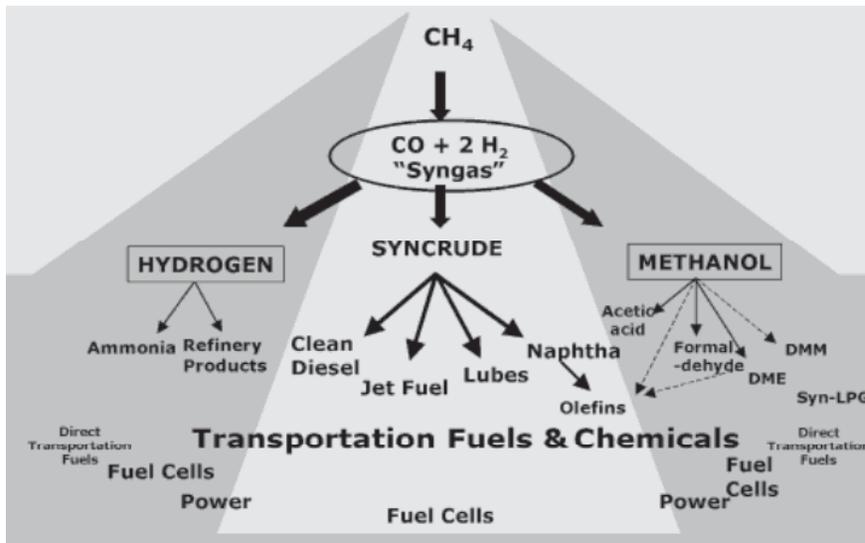


a GTC based industry can:

- Supplement profits
- Diversify income streams - hedge volatility
- Products usually linked to oil
- Provide employment opportunities for locals

But:

- Too capital intensive
- Serious competition from Middle Eastern industries



Source: Fleisch (2002)

Gas to Electricity (GtW) - Cyl

- Scope is to serve regional markets
- Export is in units of electricity (kWh), so comparisons are not so straightforward
- A consortium already lobbying (EuroAsia interconnector)
- Investment for exporting all available gas similar to an LNG plant

LNG - Main focus

Pipeline options

GTL, GTC, CNG, GtW



a GtW solution can:

- Diversify income streams - hedge volatility
- End Cyprus' electrical isolation
- Establish bidirectional link
- Ease integration of stochastic sources - renewables

But:

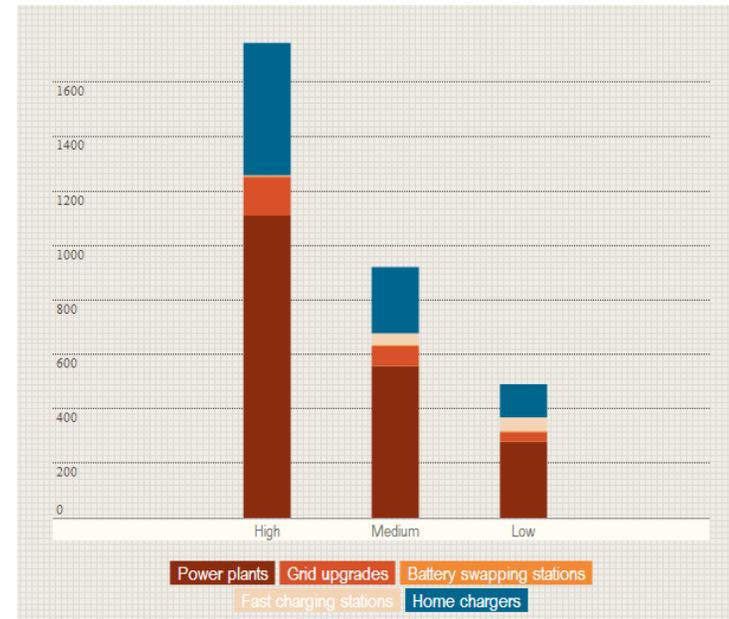
- Too capital intensive
- No destination flexibility
- Technically challenging

Demand-side considerations: Electric vehicles



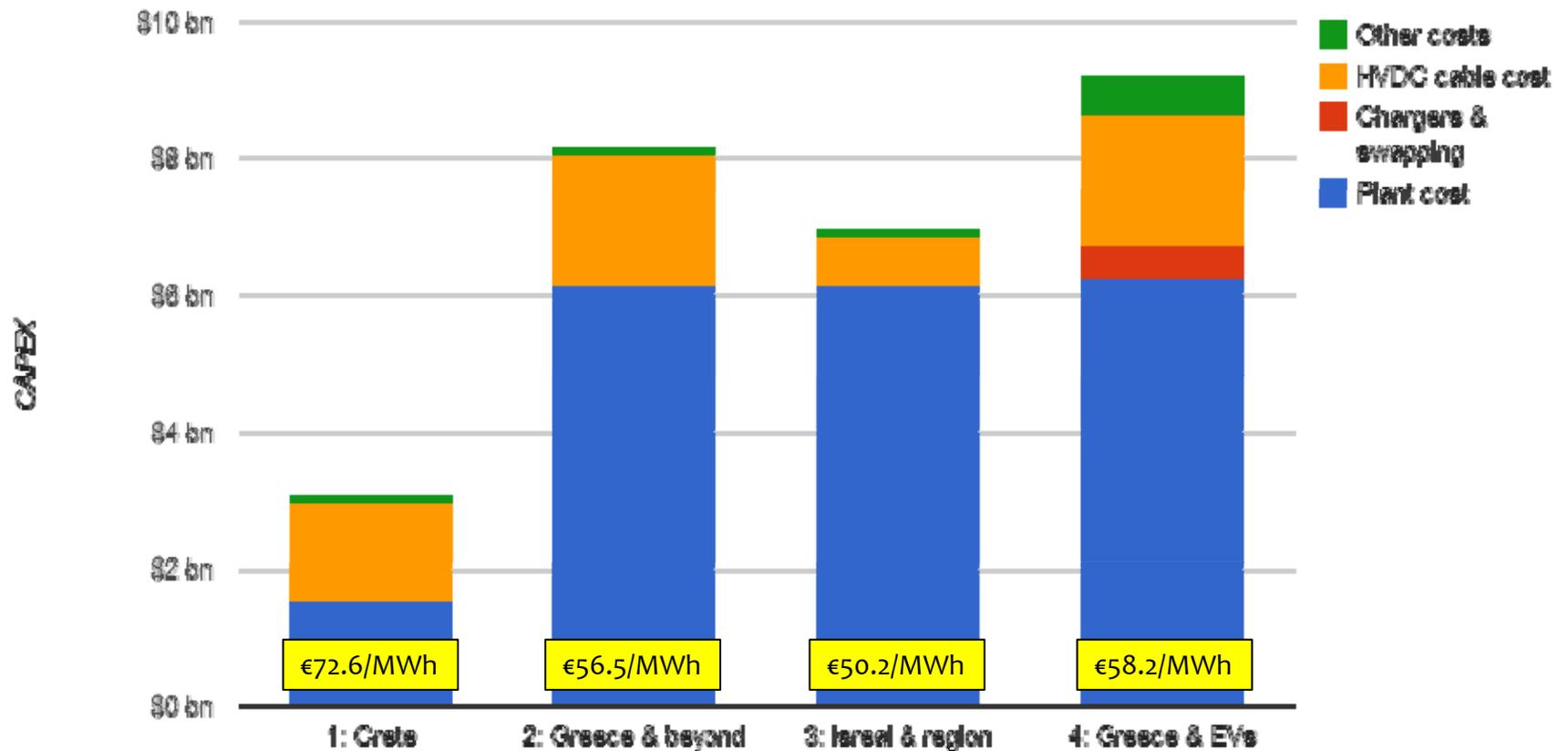
- 3 scenarios of penetration - High, Medium, Low
- Aggressive scenario (high) would require around \$1.7m in infrastructure
- An additional ~700 MWe of electrical capacity would be required
- Equivalent of 0.72 tcf in a period of 20 years

- Sub-project undertaken within the Cyprus Institute
- Quantities available for export will be less, but internal savings are considerable
- Trip patterns in Cyprus match EV characteristics very well



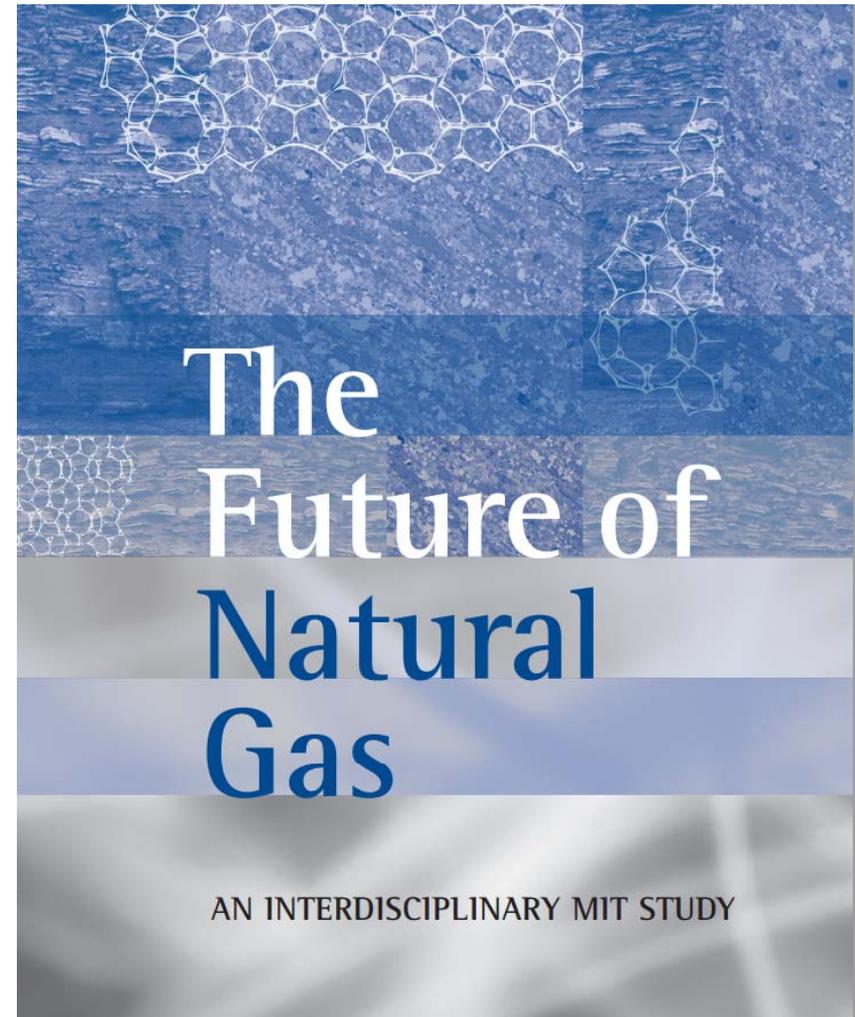
Source: Author calculations

CAPEX and break even electricity prices



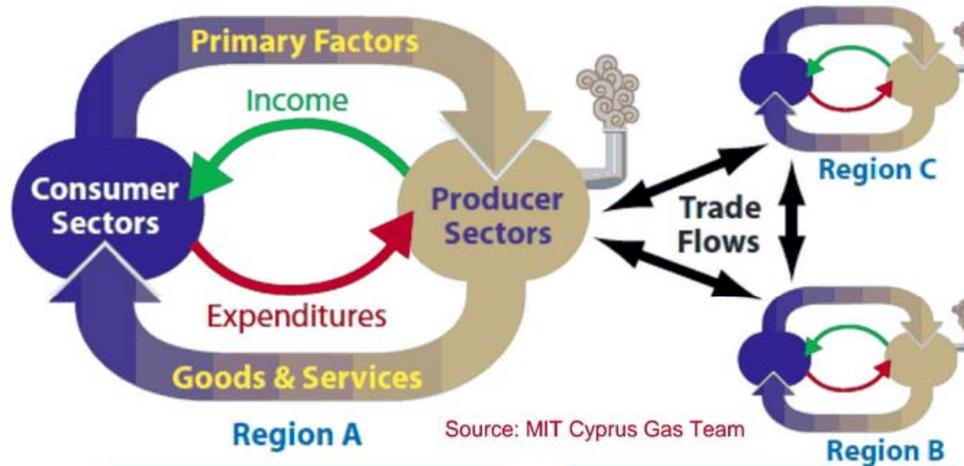
The future: Market analysis and forecasts

- 2nd (and final) phase of the report will focus on market scenarios
- The future of Cyprus decisions will be assessed
- Scenarios will be generated by using MIT's Emissions Prediction and Policy Analysis (EPPA) tool
- Tool used for landmark publications in the NG field, such as the 'Future of Natural Gas' by MITeI



The EPPA model

- EPPA is a recursive-dynamic general-equilibrium model
- Takes into account intra and inter-sector dynamics



Breakdown of EPPA's produce and consumer sectors

Non-Energy producer sectors:

- Agriculture
- Energy intensive
- Transport
- Other industry
- Services

Consumer sectors:

- Own-supplied transport
- Purchased transport
- Other goods and services

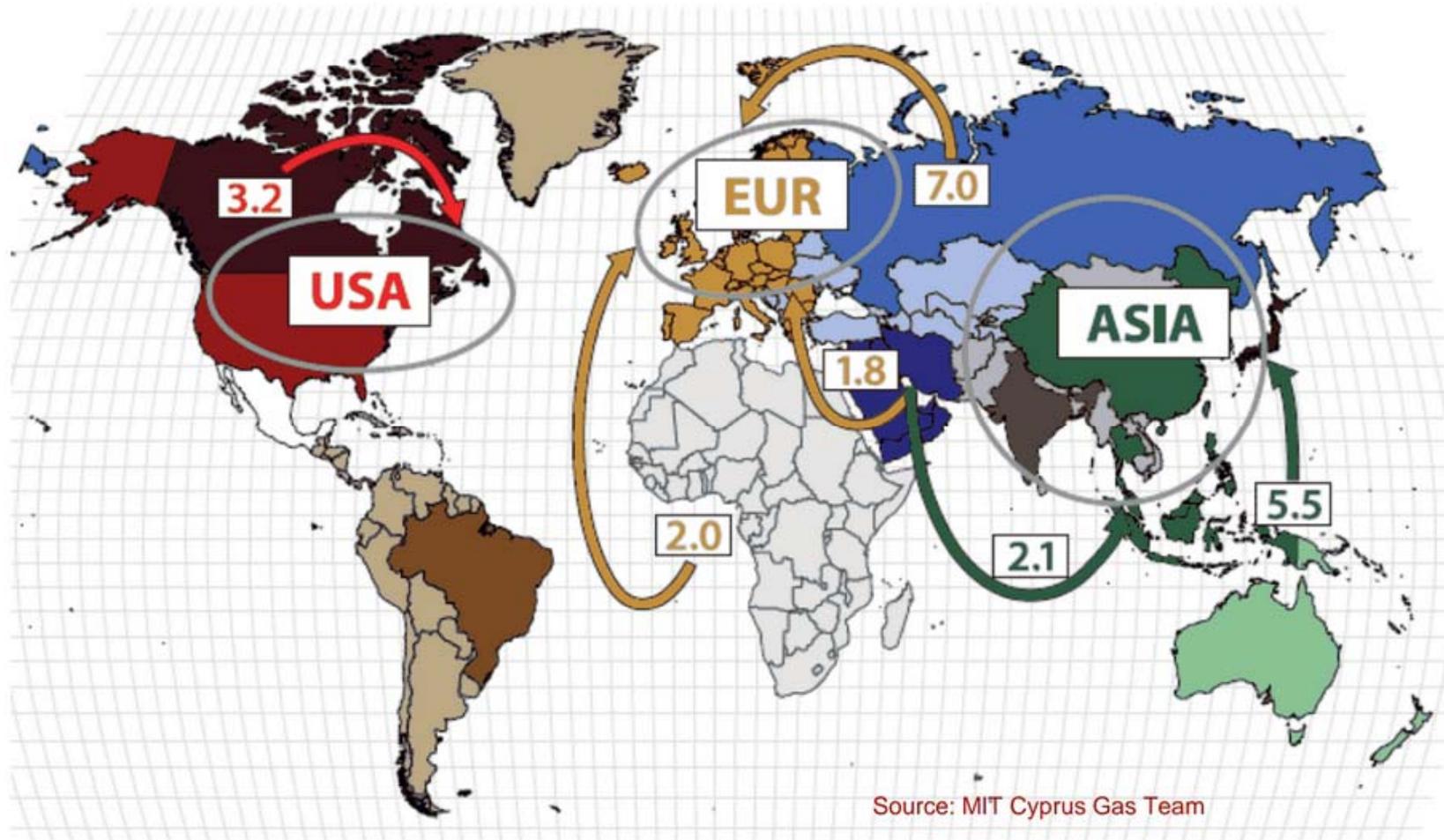
Energy producer sectors:

- Electricity
- Conventional oil
- Shale oil
- Liquid bio fuels
- Refined oil
- Coal
- Natural gas
- Gas from coal

The EPPA model (cont.)

Inter-regional LNG and pipeline gas trade in 2030 assuming a 'three-market' structure

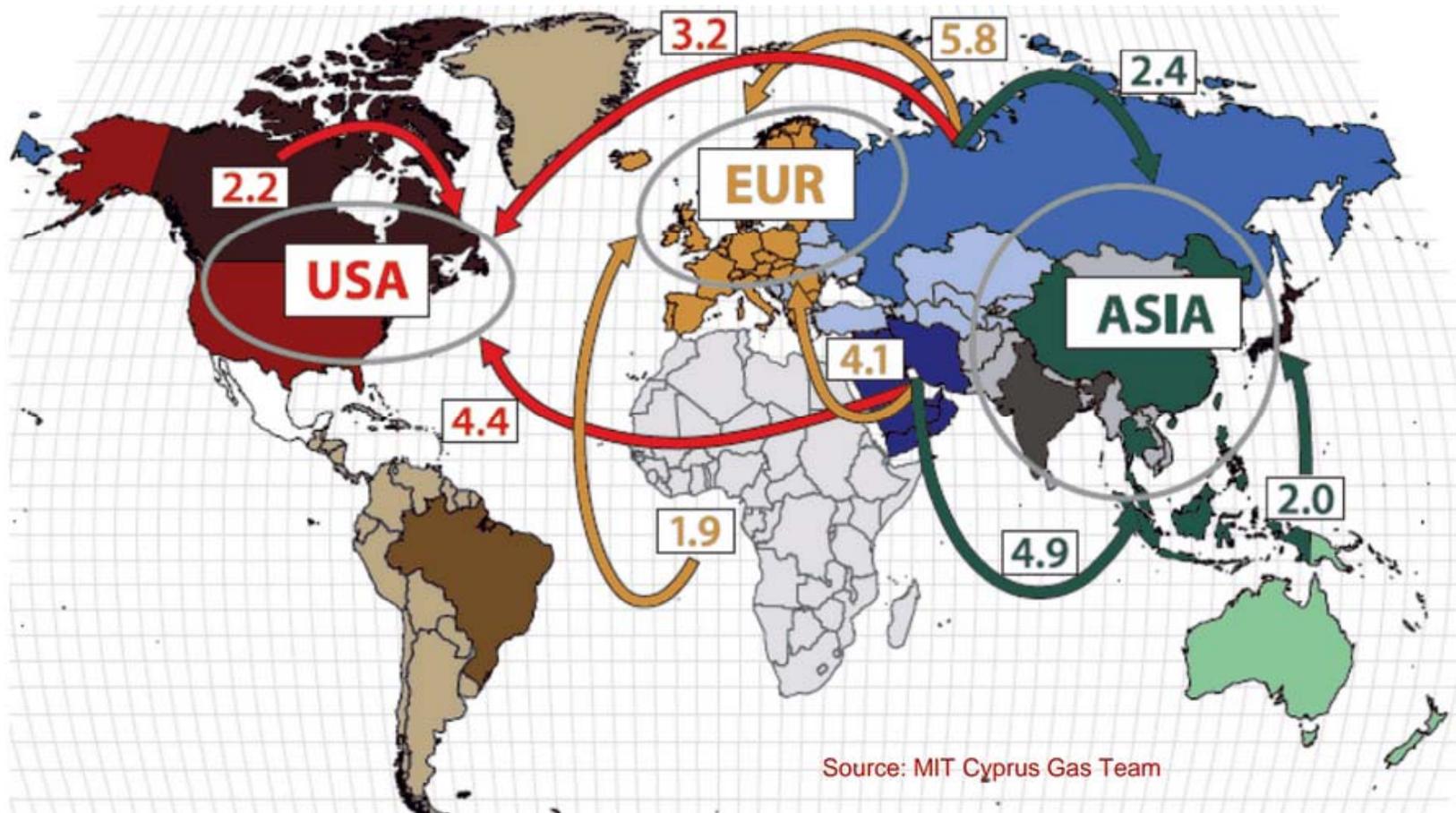
All flows in tcf



Source: MIT Cyprus Gas Team

The EPPA model (cont.)

Inter-regional LNG and pipeline gas trade in 2030 assuming a true global 'gas-on-gas' market
All flows in tcf



Concluding remarks

- Current NG market structure gives Cyprus a range of options, none of which seems optimal
- **LNG** is the only option that allows for short-term contracts anywhere in the world
- It is, however, intensely capital intensive
- Current reserves probably not enough to justify a single train - either we have to wait for additional discoveries or hammer out alliances
- A possible separate option is to use Egypt's idle capacity
- **FLNG** might be an option worth considering
- **Pipeline** construction is risky because it ties exports to one market (European)
- Greece unlikely to be able to absorb export pipeline capacity - reaching central Europe increases costs to LNG levels

Concluding remarks (cont.)

- Preliminary engineering data show **CNG** to be an economically attractive option
- It is, however, at the very early stages of maturity and carries risk and uncertainty on the final cost
- **GTC** and **GTL** depend on the composition of reserves - 'dry' gas is not so accommodating
- They are also very capital intensive and competition from neighbouring regions make the prospect risky
- **GtW** is capital intensive and carries cost uncertainties
- Combined with an internal demand spike however, it can become a viable alternative for regional electricity markets
- Market analysis in the next stage will provide a much better context for all the options

Thank you

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