A TIMES study for the assessment of the future unconventional oil and gas markets. An application of the JRC ETM

Workshop on energy models and applications jointly organized by the Research Centre for Gas Innovation (University of Sao Paulo) and ETSAP

Auditório do Departamento de Engenharia Metalúrgica e de Materiais,
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Overview

1. Objectives
2. Methodology
3. Scenarios implementation
4. Modelling Results

Objectives

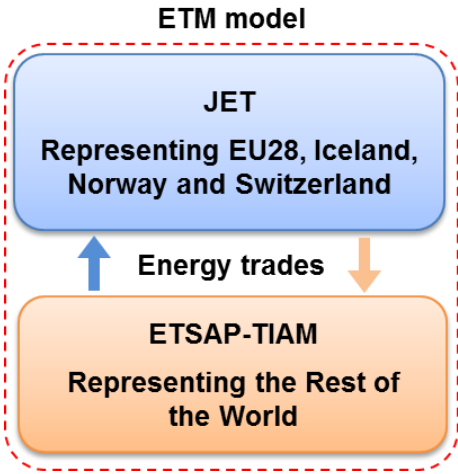
The key objectives of the present study are:

- to quantitatively explore the medium and long-term potential (up to 2040) development of unconventional hydrocarbons at global scale; namely
  - Unconventional gas: coal bed methane, tight gas and shale gas
  - Unconventional oil: extra-heavy oil, oil sands and tight oil.

- to assess its possible impacts on the European market.

JRC ETM model

- The analysis has been developed using the JRC Energy Trade Model (JRC ETM).
- The JRC ETM model is a TIMES world model that hard-links the global multi-regional ETSAP TIMES Integrated Assessment Model (ETSAP-TIAM), and the JRC EU TIMES model (JET) of Europe.
- The ETM model is a large partial equilibrium model of the global energy system. It represents 44 separate regions: 13 World regions of the ETSAP-TIAM and 31 countries of JET model.



- The JRC ETM provides a range of energy system configurations, each one delivering projected energy service demand requirements optimised to least cost and subject to a range of policy constraints for the period up to 2040.
- It assess the impacts of energy policy choices and scenarios with respect to:
  - the economy (technology choices, prices, output, etc.);
  - the energy mix; and
  - the carbon emissions.

The TIMES model generator

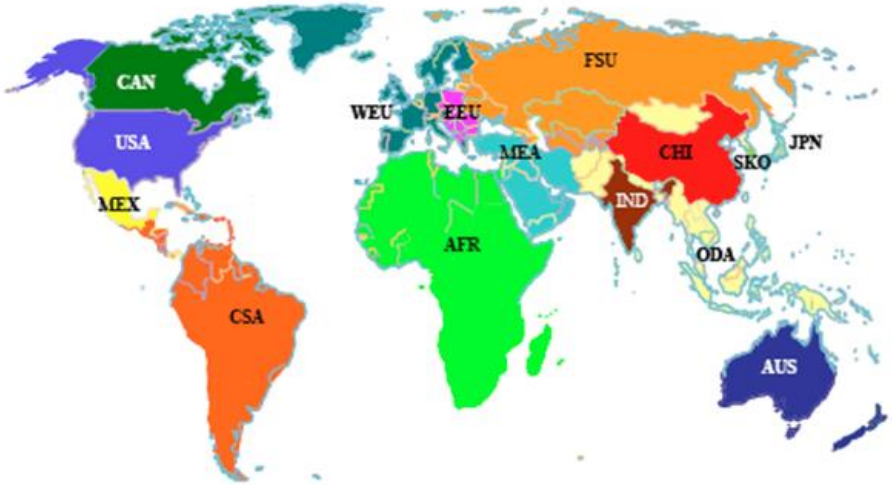
- The Integrated MARKAL-EFOM System (TIMES) is the technical economic model generator of ETSAP, one of the TCP of the International Energy Agency.
- Very similar to MARKAL but with significantly improved features and modelling capability.
- It builds partial equilibrium linear economic models, providing a technology rich basis (bottom-up approach) for estimating energy dynamics over a long-term, multiple period time horizon.
- The optimisation maximises the total discounted surplus, over the entire time horizon within environmental and technical constraints.

The ETSAP-TIAM model

The ETSAP-TIAM model includes 15 regions.

It has the following characteristics:

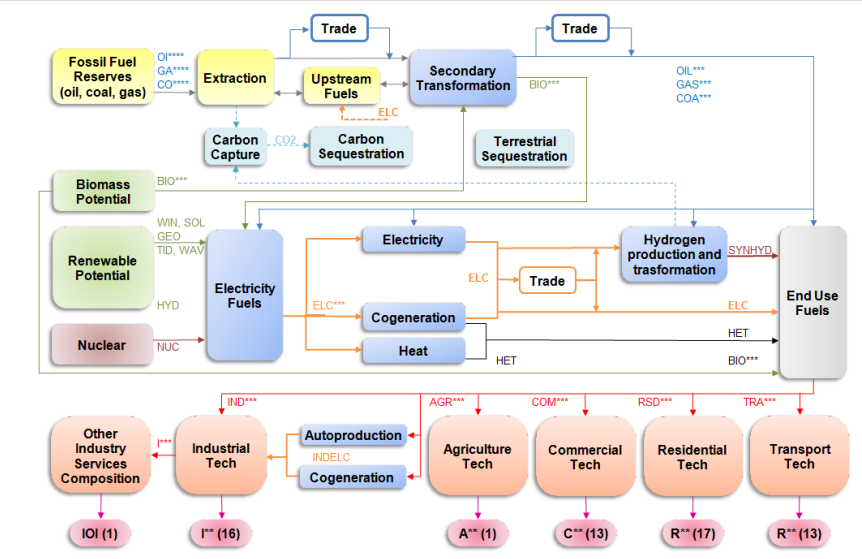
- Base year 2005.
- Long term horizon up to 2100.
- Region-dependent technical economic data.
- Demands driven by results of the global CGE model.
- Explicit descriptions of more than 1 000 technologies and 100 commodities (energy forms, materials, emissions), logically interrelated in a Reference Energy System covering extraction, processing, conversion, trading and end-uses of all energy forms.

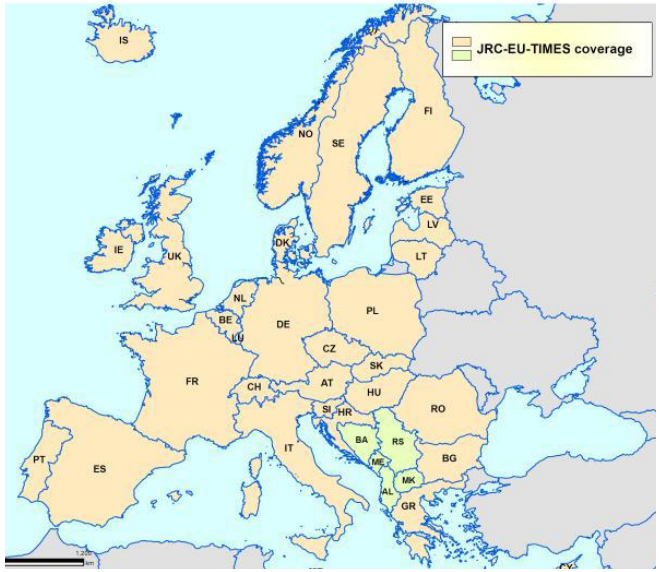


The JET model

The JET model includes 31 regions and it has the following characteristics:

- Base year 2005.
- Long term horizon up to 2075.
- Country-dependent technical economic data.
- Demands driven by results of the global CGE model.
- Explicit descriptions of more than 2000 technologies and 70 commodities (energy forms, materials, emissions), logically interrelated in a Reference Energy System.



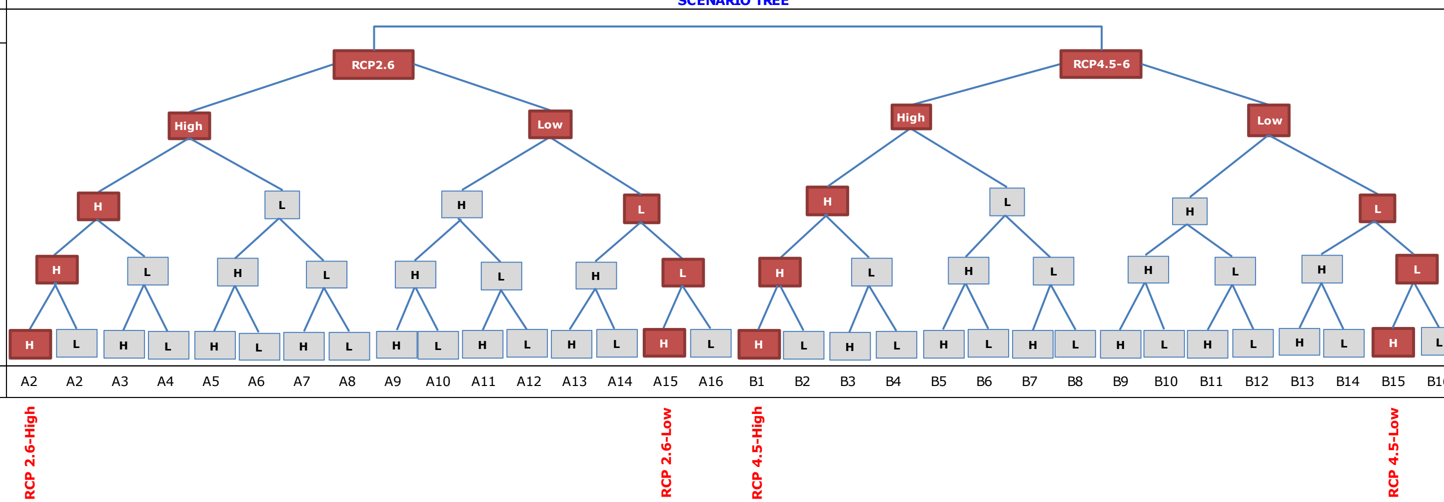


Scenarios implementation

- Based on the identification of the following key variables
  - ➢ Stringency of climate policies.
  - ➢ Potential of unconventional gas and oil resources.
  - ➢ UH extraction outlooks costs in key countries.
  - ➢ Development of global gas market.
  - ➢ Demand side.
- The following possible storylines can be identified:

CRITICAL VARIABLES:	supply chain	time horizon
Stringency of climate policies	all	2020-50
Potential of unconventional gas and oil resources	Oil/Gas supply	2020-30
UH extraction outlooks costs	Oil/Gas supply	2025-40
Development of global gas market	trade	2020-50
Demand side	final consumption	2030-50
Scenario composition		

SCENARIO TREE



Scenarios implementation

Four alternative scenarios have been analysed:

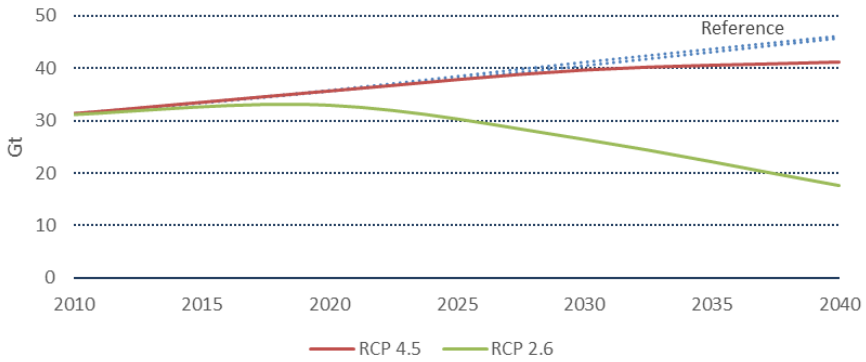
1. considering two different climate policies based on the last IPCC report (RCP 4.5 and RCP 2.6).
2. considering high and low outlooks of UH resources/costs, and market development;
3. assuming the same levels of energy service demands to enable a direct comparison between the scenarios.

Summary of the four scenarios assumptions

Scenario name	Climate trajectory	UH Potentials	UH Costs	Development of gas markets	Demand
RCP 4.5-Low	RCP 4.5	Low	Low TL	Low	Rigid
RCP 4.5-High	RCP 4.5	High	High TL	High	Rigid
RCP 2.6-Low	RCP 2.6	Low	Low TL	Low	Rigid
RCP 2.6-High	RCP 2.6	High	High TL	High	Rigid

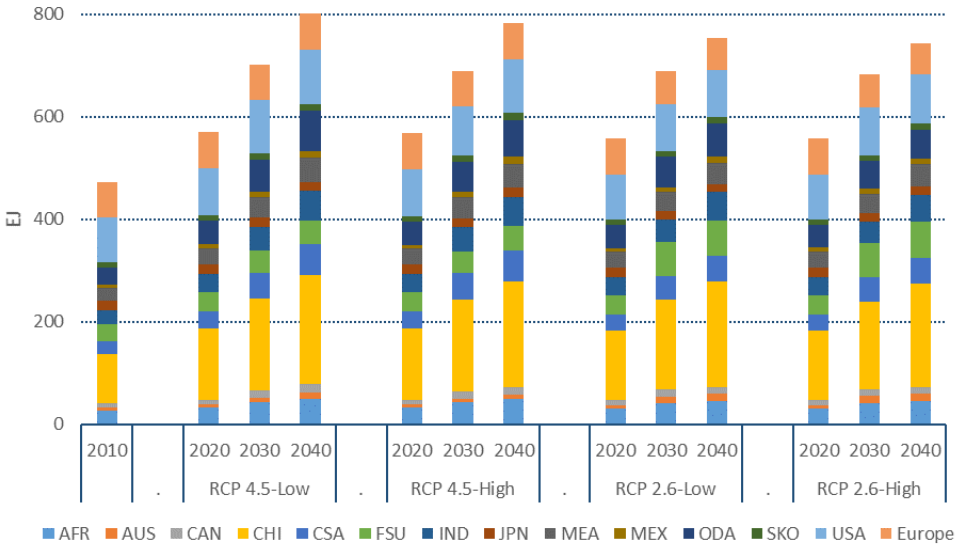
Modelling results – Global trends

CO_2 emissions trajectories (Gt)



- In the RCP4.5 scenario, the emissions level in 2040 is 31% higher than 2010.
- In the RCP2.6 scenario, the emissions level in 2040 is 44% lower than 2010.

Global primary energy demand (EJ)



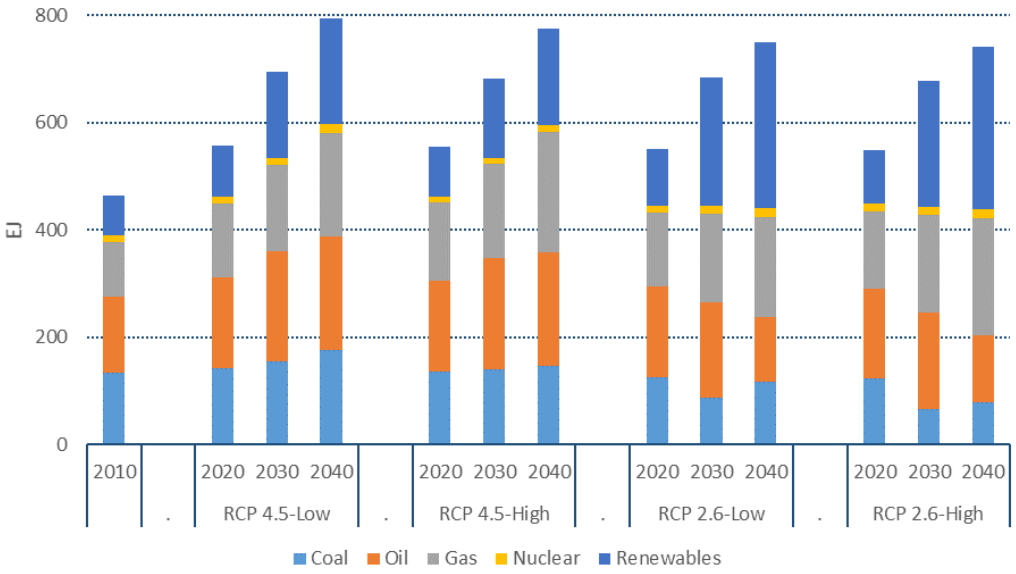
Global CO_2 Marginal prices ($€_{2010}$/tonne)

Scenario	2020	2030	2040
RCP 4.5-Low	0	8	29
RCP 4.5-High	0	3	28
RCP 2.6-Low	20	150	698
RCP 2.6-High	17	140	674

Average exchange rate 1 $€_{2010}$ = 1.33 US_{2010}$)

Modelling results – Global trends

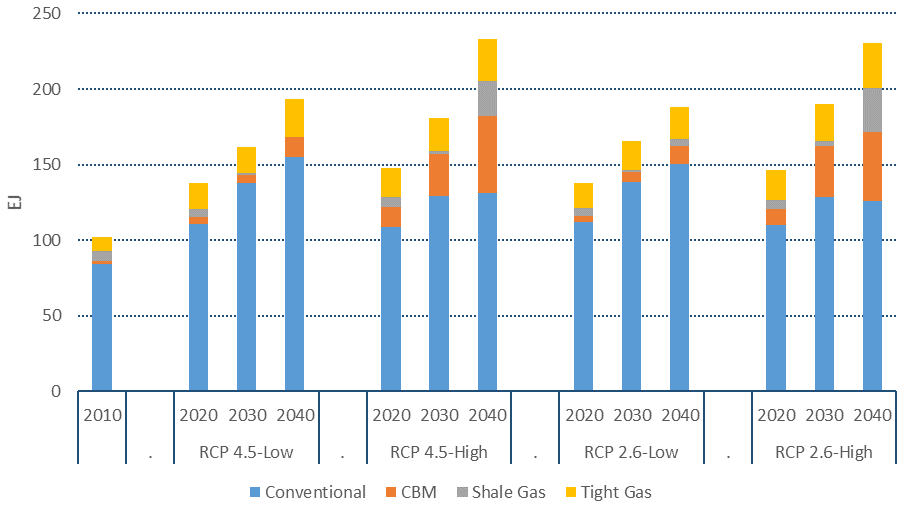
Global primary energy demand (EJ)



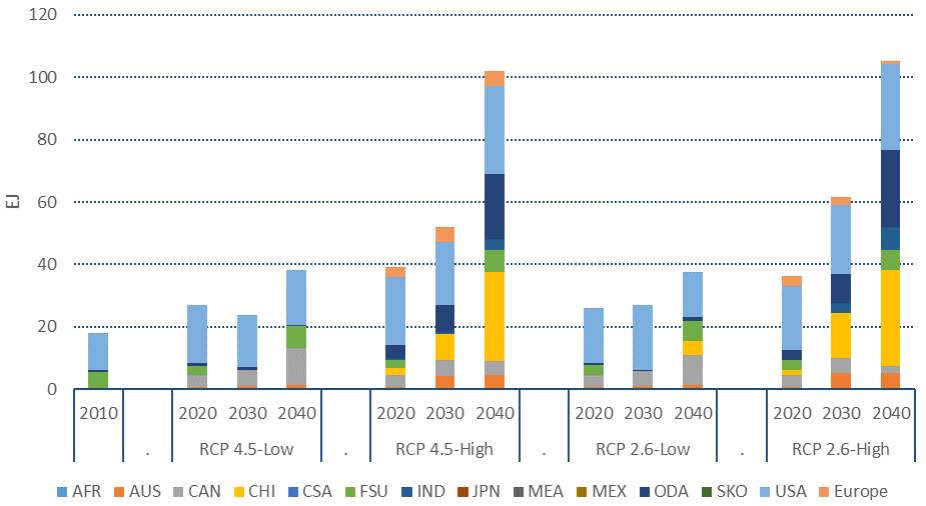
- Natural gas has a key role on meeting increased energy demands
  - 84% - 90% higher than in 2010 in LOW scenarios
  - 113% - 120% higher than in 2010 in HIGH scenarios
- Oil demand increases under the RCP 4.5 scenario, while under RCP 2.6 scenarios its demand rapidly declines in 2040
- Renewables demand increases in all selected scenarios.

Modelling results – Natural gas markets

Global Natural Gas production (EJ)



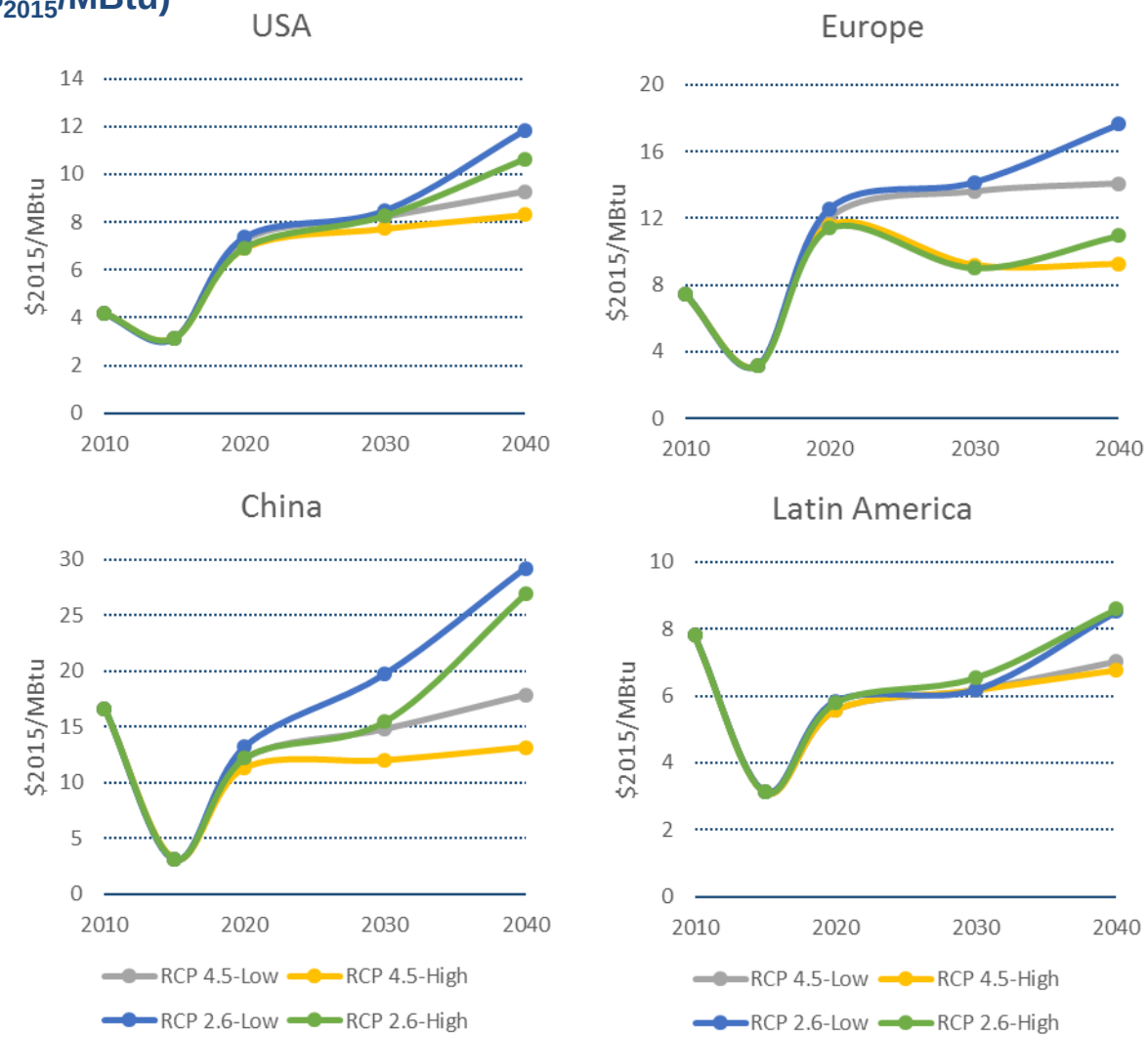
Unconventional Gas production (EJ)



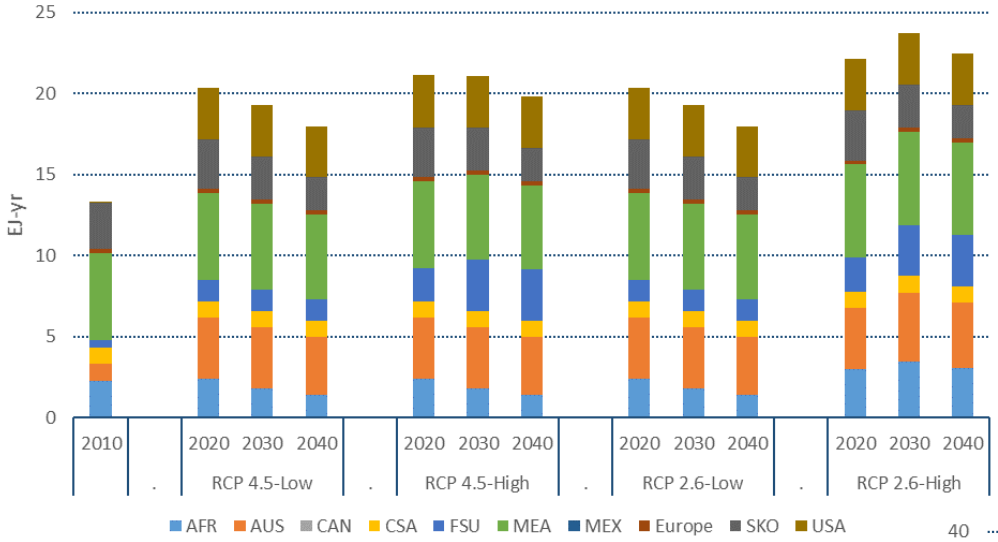
- Unconventional gas industry will have an increasing role in future gas markets.
- In the HIGH scenario in 2040 the UG:
  - Represents 44%-46% of overall gas production.
  - United States (USA), Middle East (MEA) and Former Soviet Union (FSU) are forecasted to continue to have a strong role as gas producer in the future gas markets (conv. and unconv.).
  - New emerging regions on UG production: CHI, ODA.

Modelling results – Natural gas markets

Natural gas price ($\$_{2015}$/MBtu)



Gas liquefaction capacity (EJ-yr)



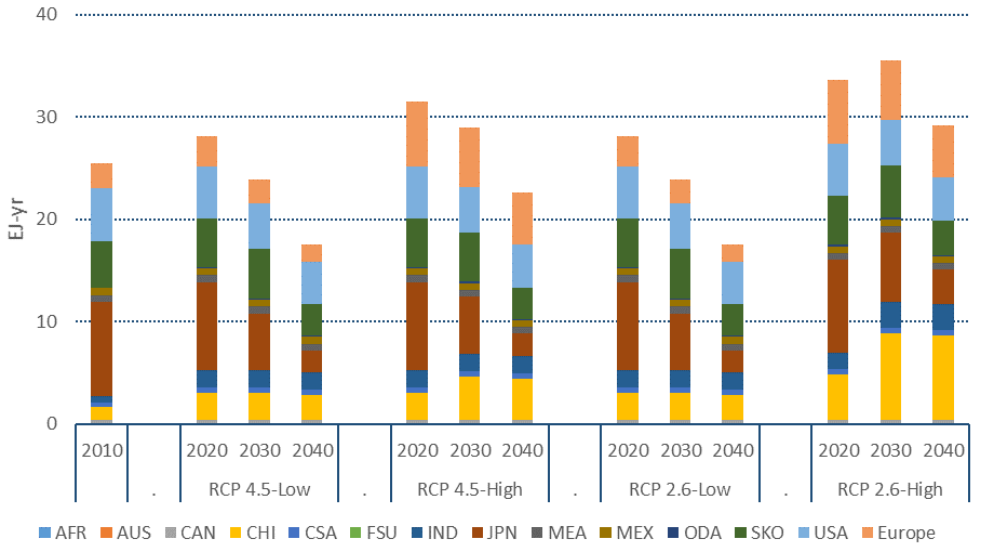
1. The LOW scenarios include only the existing capacities and/or under-construction today.

2. The HIGH scenarios include the possibility to expand the existing/under-construction capacity endogenously based on underdevelopment projects (proposed or FEED).

3. The liquefaction capacity is expanding in AUS in all scenarios, in AFR in the RCP 2.6 and in FSU in the HIGH scenario.

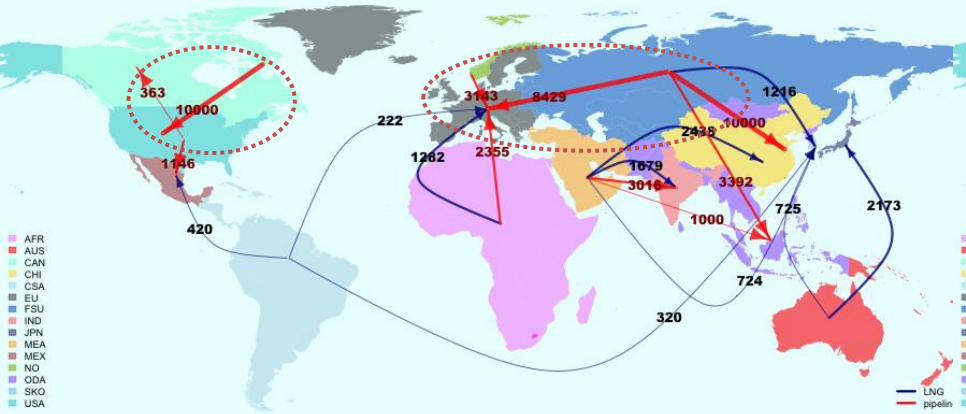
4. The gasification capacity is expanding mainly in CHI and EU.

Gas gasification capacity (EJ-yr)

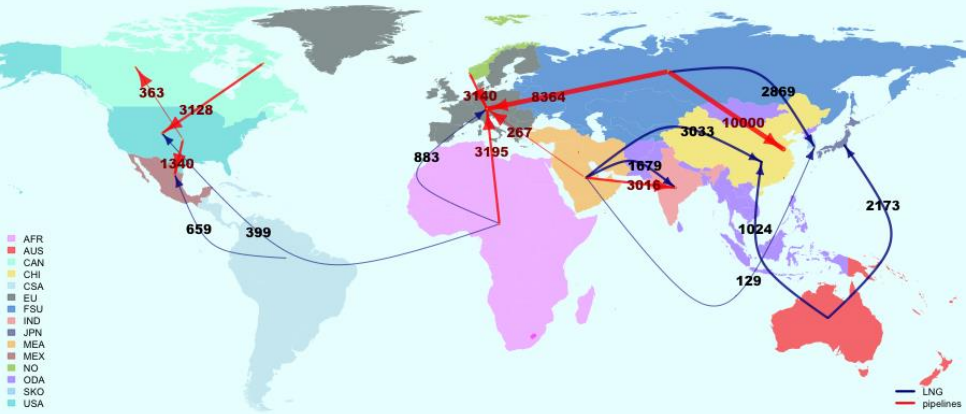


Modelling results – Global gas trade

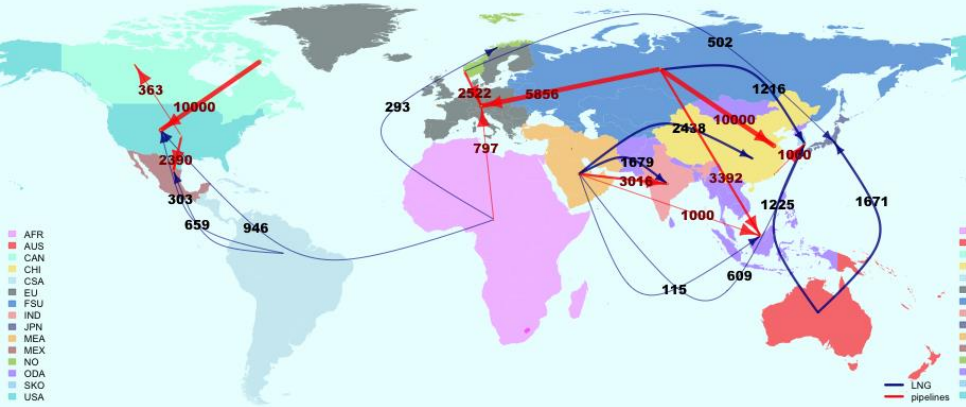
RCP 4.5-Low (PJ)



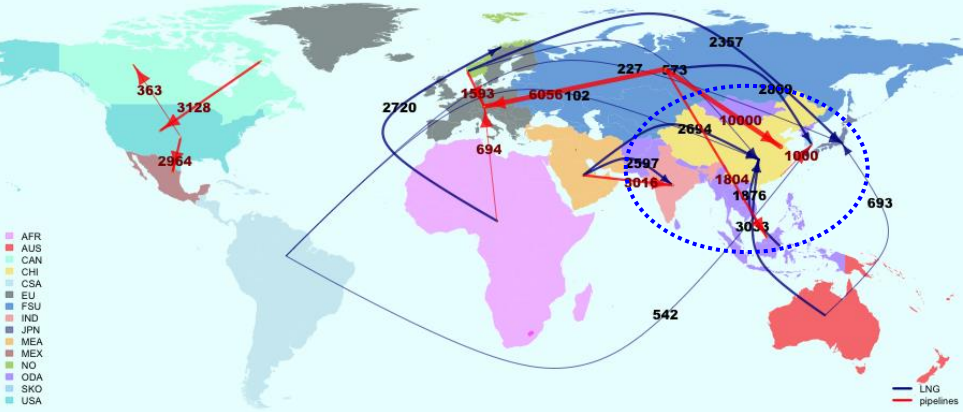
RCP 4.5-High (PJ)



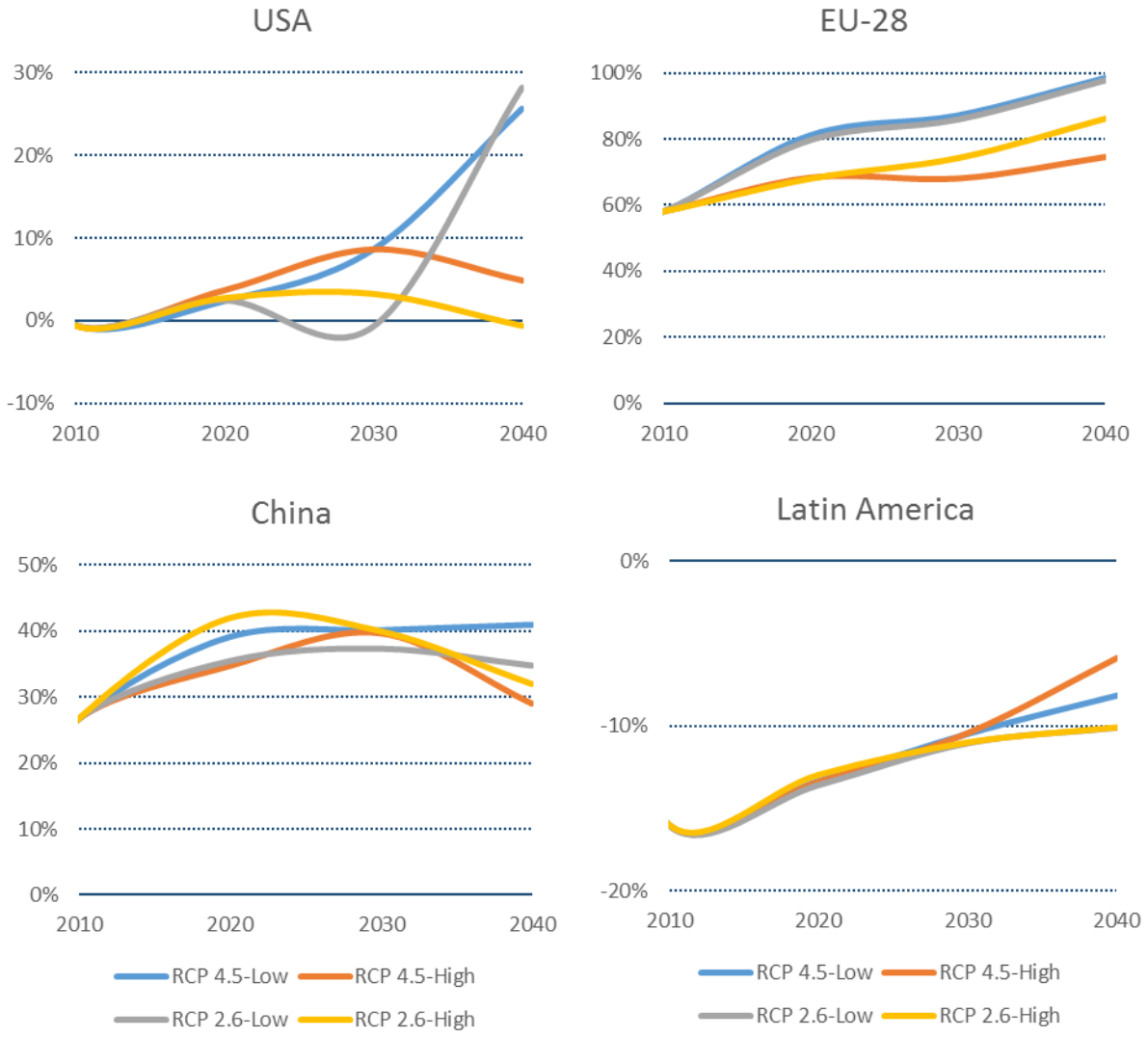
RCP 2.6-Low (PJ)



RCP 2.6-High (PJ)

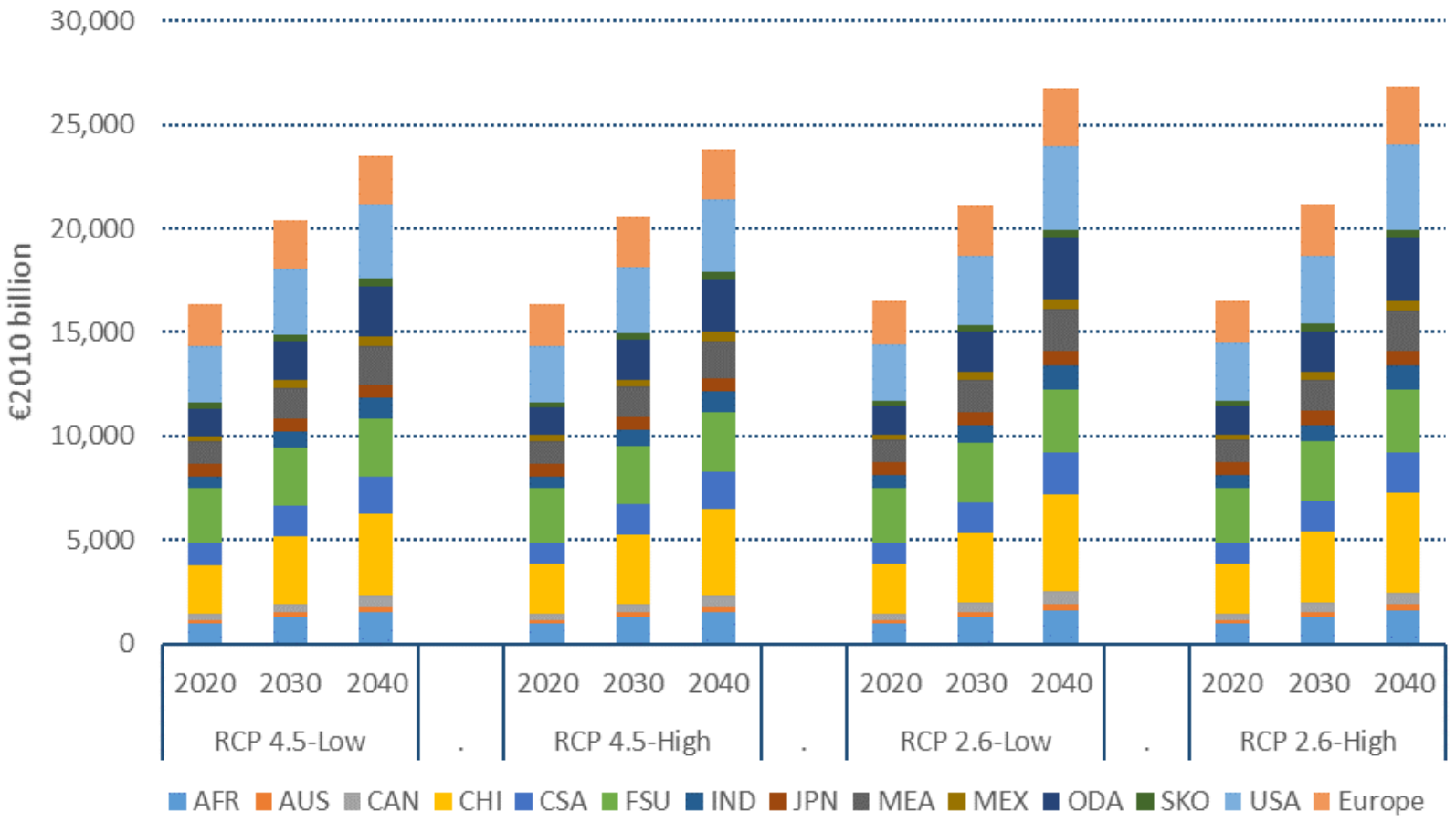


Modelling results – Natural gas import dependency

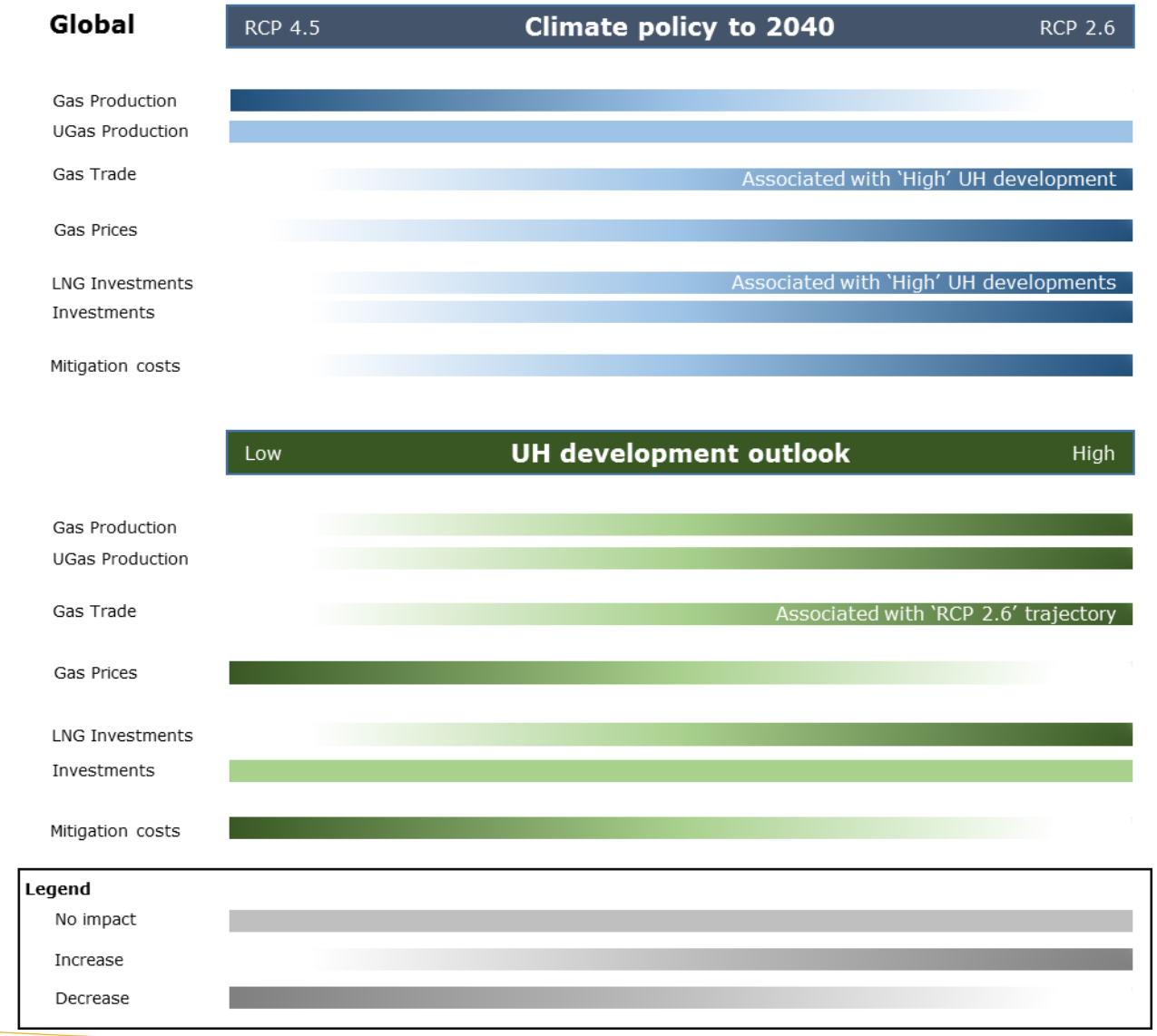


Global energy-related investments (€$_{2010}$ billion)

(Average exchange rate 1 €$_{2010}$ = 1.33 US$ $_{2010}$)



key variables influencing the development of UH gas



key variables influencing the development of UH

- **Gas production**
  - Climate targets have small impacts on future global gas production.
  - ‘High’ UH outlooks drive to higher gas extraction levels.
- **Gas demand**
  - Strong mitigation policies have the effect of reducing gas demand in the EU energy system by 2040, i.e. gas is used as transition fuel.
  - For other realities, e.g. China or US, gas replaces other more carbon intensive fossil fuels, contributing to decarbonisation.
- **UH**
  - Unconventional gas market share increases under ‘High’ scenarios.
- **Gas prices**
  - ‘High’ UH development outlooks result in lower fuel prices.
  - Stronger mitigation policies drive to higher gas prices.
- **Investments**
  - Climate targets are the main drivers for increased investment levels in the energy system.
- **LNG infrastructure**
  - ‘High’ UH development outlooks associated with strong mitigation targets lead to higher investment in LNG infrastructure.

Chiodi, A., Gargiulo, M., Gracceva, F., De Miglio, R., Spisto, A., Costescu, A., Giaccaria, S., *Unconventional gas and oil resources in future energy markets. A modelling analysis of the economic impacts on global energy markets and implication for Europe*, EUR 28275 EN, doi: 10.2790/83538

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