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3-2. Outlook of Industry Sector

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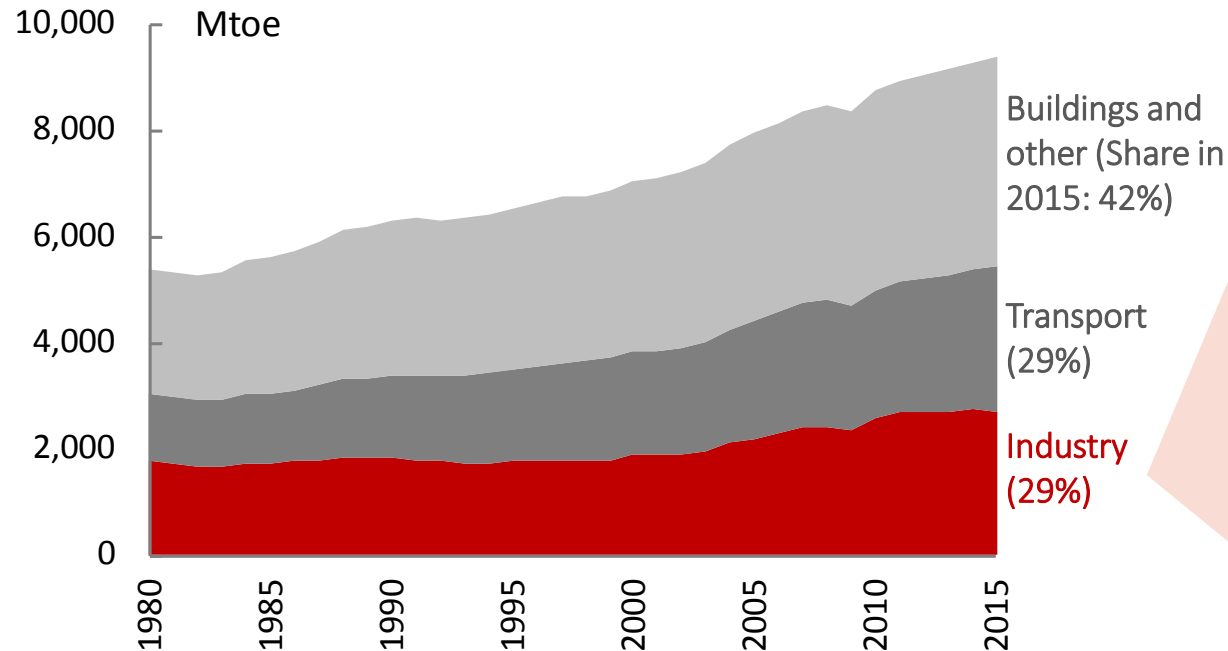


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- | Industry sector overview
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Industry has been accounting for about one-third of the global final energy consumption

Global final energy consumption



- Iron and steel
- Non-metallic minerals
- Chemical and petrochemical
- Non-ferrous metal
- Transport equipment
- Machinery
- Mining and quarrying
- Food and tobacco
- Paper, pulp and printing
- Wood and wood products
- Construction
- Textile and leather
- Non-specified industry

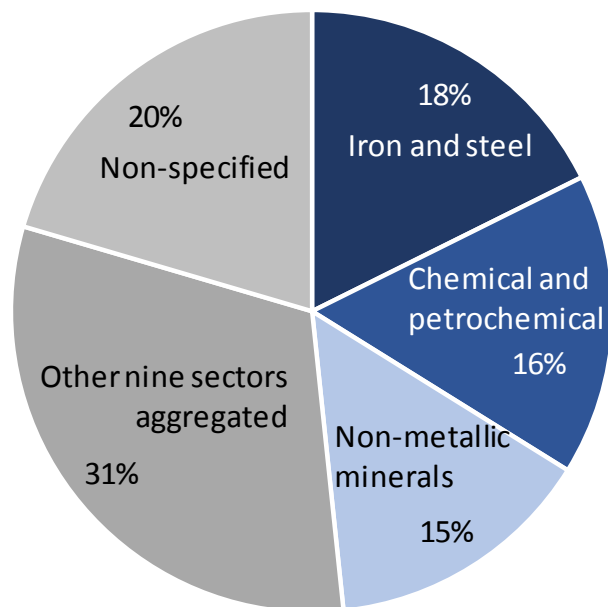
| 13 industries are included in the sector

| The share of industry in APEC has also been about one-third (28-34%) since 1980

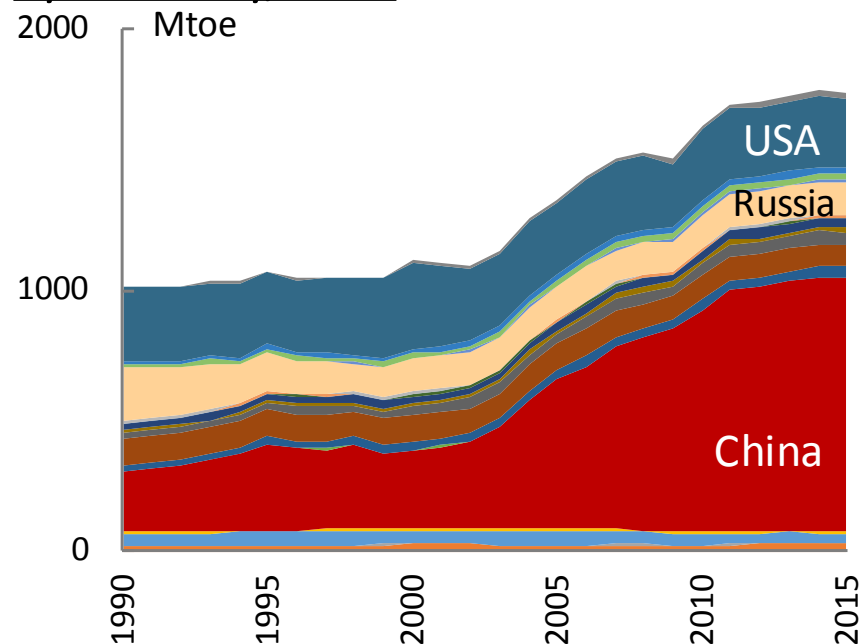
Note1: As of 2015. Data from IEA.

Iron & steel, non-metallic minerals and chemical/petrochemical are the three largest energy consuming industries

Global energy consumption in industry by sub-sector, 2015



APEC energy consumption in industry by economy, 2015



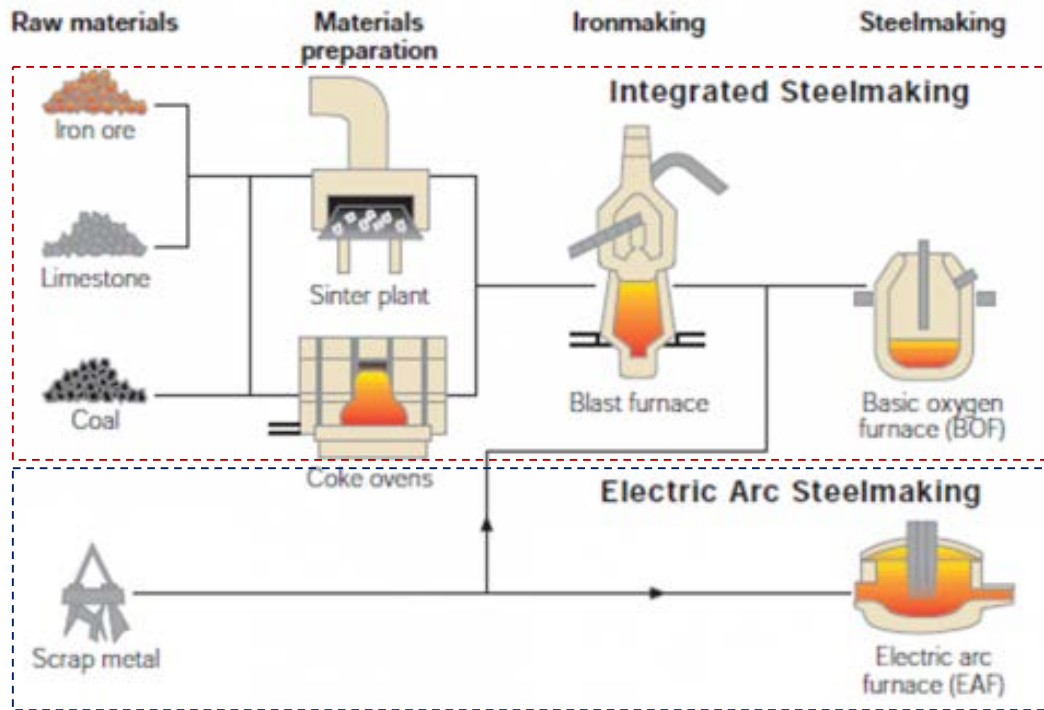
- | These three sectors currently account for almost half of total energy consumption in industry
- | Among APEC economies, China has driven the industrial demand growth in the 2000s

Note: Data from IEA.

Example of industrial activity:

Steel making in the iron and steel sector

Major steel making processes



Blast furnace

- Accounts for 70% of global steel production
- Coal is the main fuel for heating as well as reducing iron ore

Electric arc furnace (EAF)

- Production using Scrap and pig iron or direct reduced iron
- Electrical charge provides heat
- Less energy required compared to blast furnace

| Energy consumption profiles largely vary by process in several sub-sectors

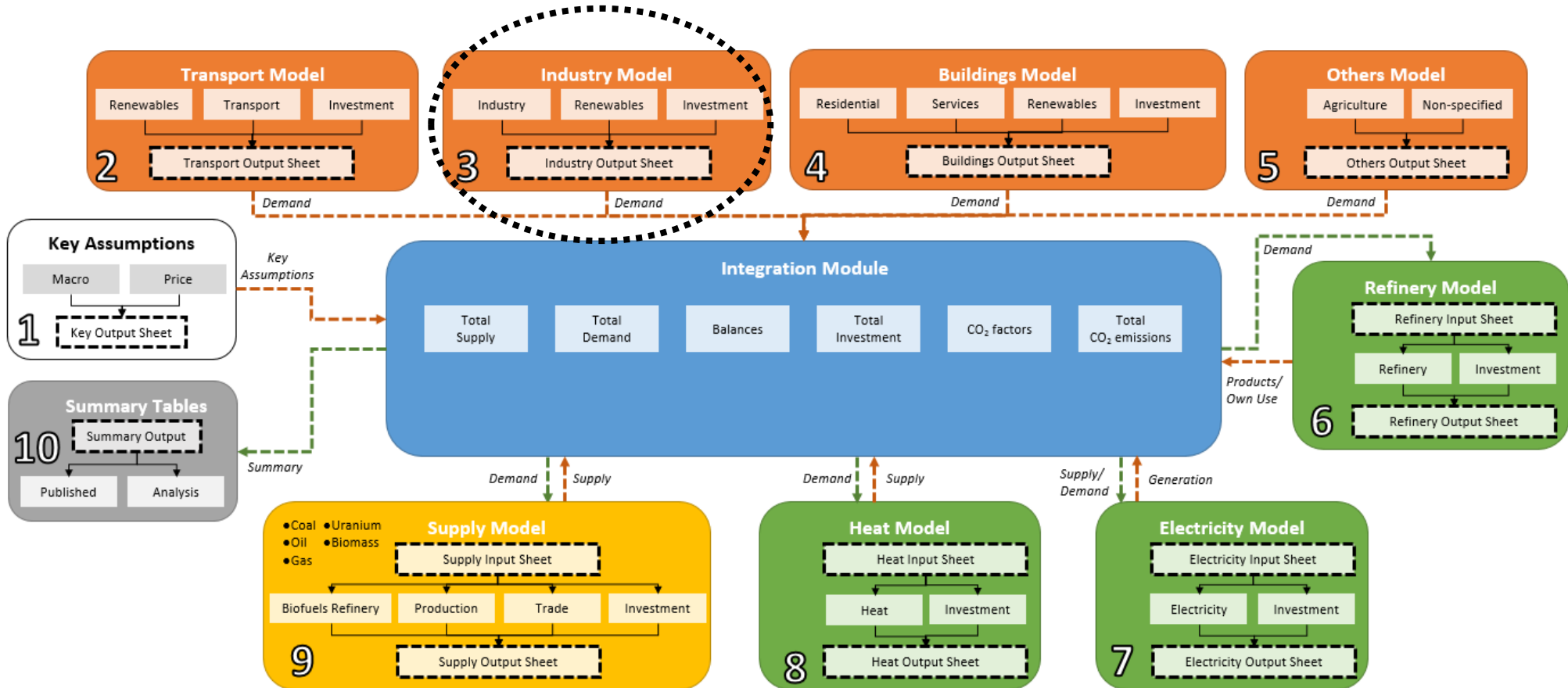
| Explicit modeling of industrial process is important for projections

Source: http://www.steelconstruction.info/images/thumb/6/61/B3_Fig4.png/500px-B3_Fig4.png



New industry model for the 7th Outlook

APERC's energy demand and supply model structure



Industry model structure

Macro assumptions

Historic production

GDP

Population



Industrial activities

Crude steel production

Chemicals
(ammonia, ethylene,
propylene, aromatics)

Cement production

Paper production

Aluminium production

Value added in the rest
of other industry



Modeled sub-sectors

Iron & steel

Chemicals &
petrochemicals

Non-metallic minerals

Pulp, Paper & Printing

Aluminium

Other industries

| 6 modeled sub-sectors

| Energy demand is estimated through projecting **industrial activities** and **energy intensity**
(energy intensity = energy consumption per unit of activity)

Selected model enhancements from the 6th model

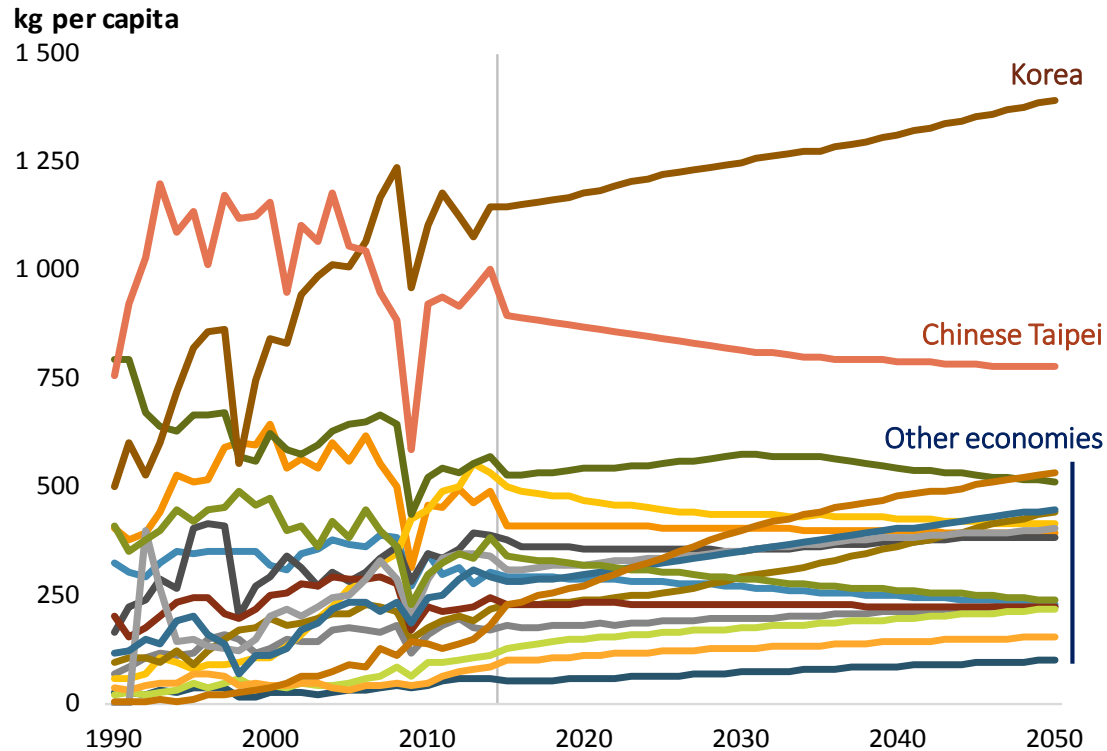
| **Industrial activity module** was created to project industrial production in physical basis in energy-intensive sub-sectors. This enables to:

- Model the impacts of sector-specific factors, including steel recycle rate, clinker-to-cement ratio and recovered paper rate;
- Analyze process emissions in cement production (calcination process), which accounts for as much as 50% of its emissions; and,
- Estimate non-energy use, such as for feedstock in the chemicals, taking into account the products in each economy.

| **Energy intensity module** was refined to assess the intensity improvements, taking into account the future choice of production processes and capacity changes (such as retirement of exiting facility and new additions)

Per capita consumption is one of the main outputs of the model

Steel consumption per capita



- | Per capita consumption is a useful indicator to implicitly reflect the socio-economic factors, including the level of social infrastructure and people's lifestyle

Source: APERC.



Preliminary results

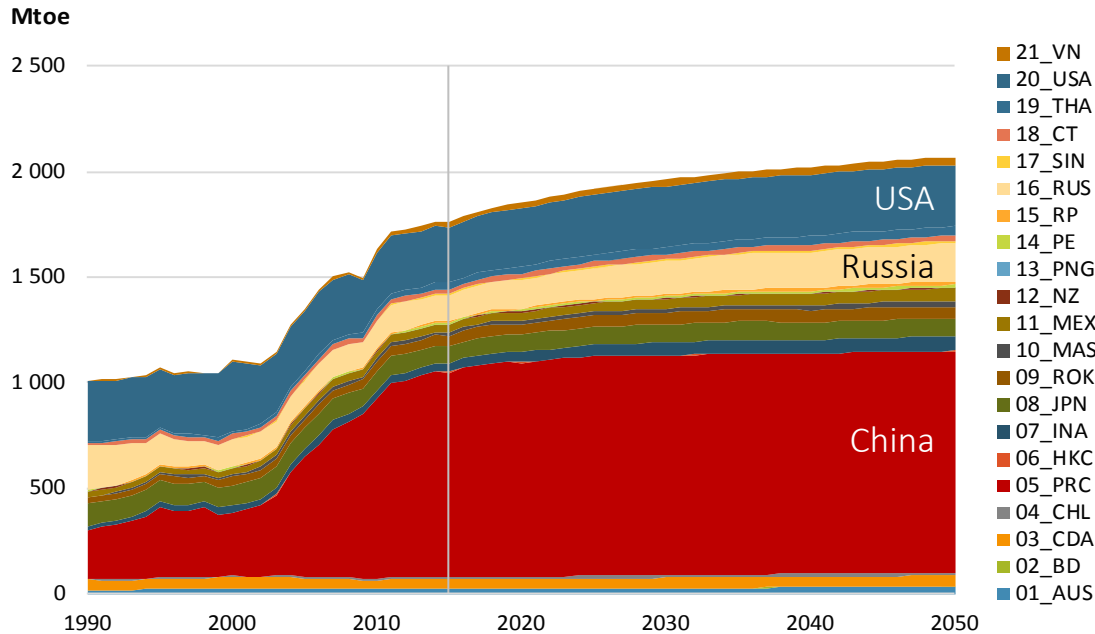
General assumptions for the “BAU” and “TGT” scenario

	Business-as-Usual (BAU)	APEC Target (TGT)
Industrial output	<ul style="list-style-type: none"> • Domestic consumption is projected based on an econometric model analyses as well as recent policies and industry views • Model input data include GDP, population and historical production 	
Energy intensity and renewables	<ul style="list-style-type: none"> • Current operation practice remains over the period in terms of efficiency and renewables 	<ul style="list-style-type: none"> • Accelerated retirements of existing facilities • BAT and efficient operation at newly added facilities • Higher renewable use as a heat supply option
Sector-specific factors	<ul style="list-style-type: none"> • Current recycle rate (steel scrap, used paper, etc.) and clinker-to-cement ratio remain 	<ul style="list-style-type: none"> • Accelerated recycle activities and higher additives for cement production

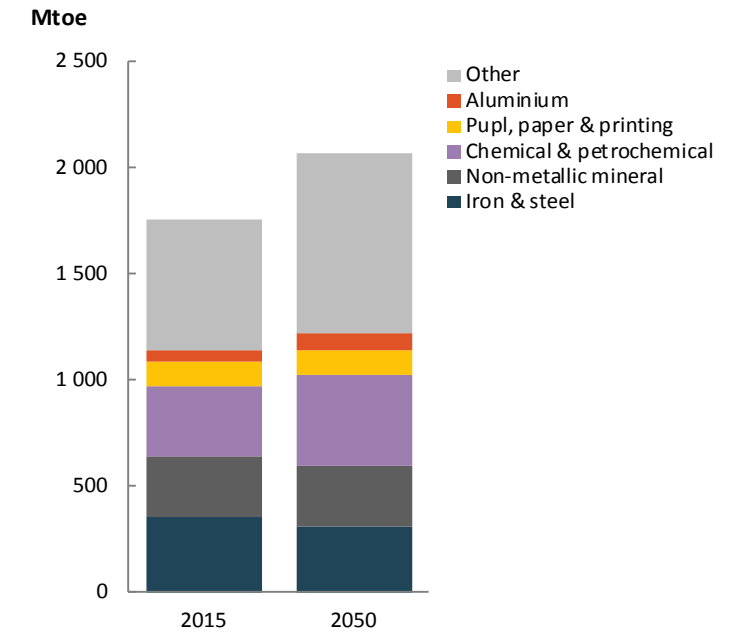
Note: BAT=Best Available Technology.

Industry energy demand in APEC continues to grow by 20% under the BAU

Industry energy demand by economy



Sub-sector demand, 2015 & 2050



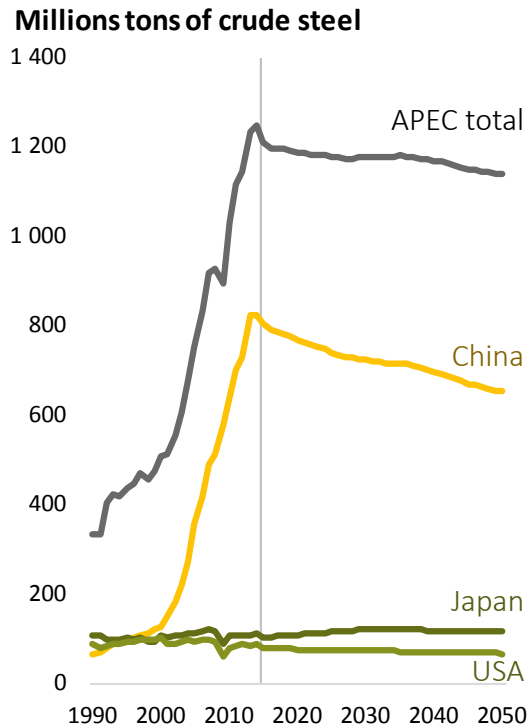
China remains the largest industry energy consumer, with a share around 50-55% from 2015 to 2050

Energy demand in iron & steel and non-metallic minerals peak, while chemicals drives the growth among the most energy-intensive industries

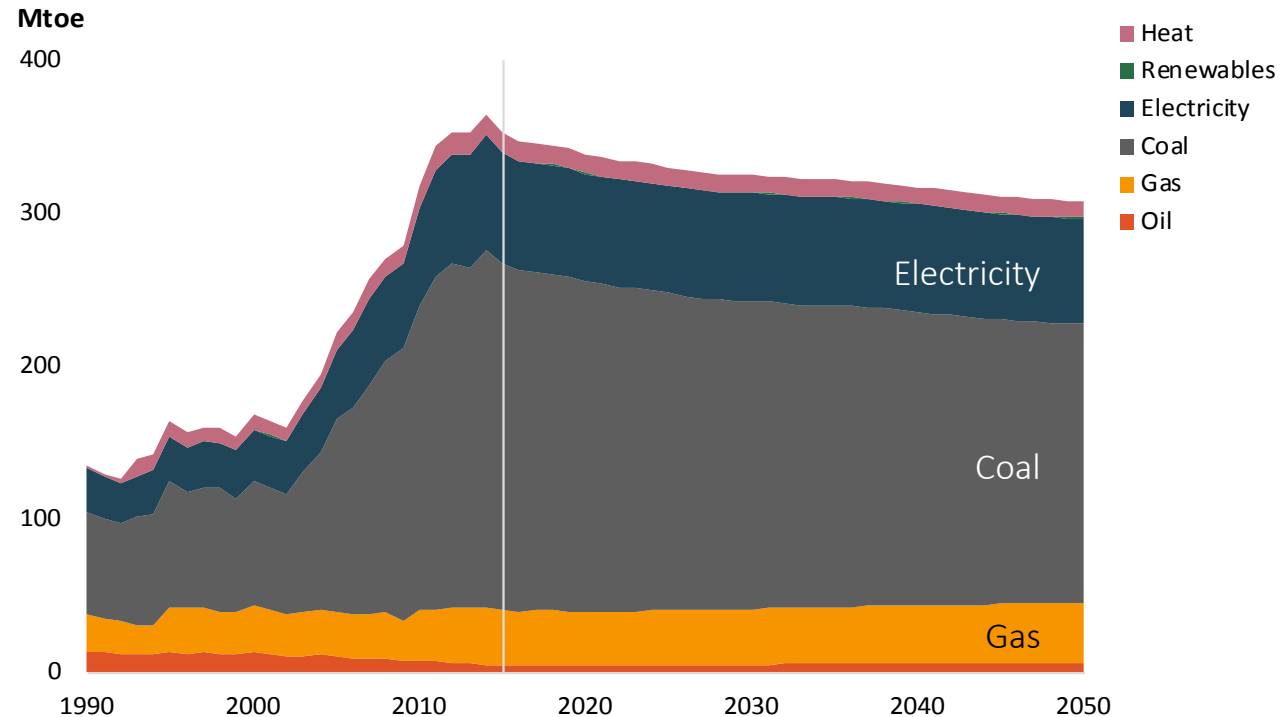
Source: APERC.

Crude steel production and energy demand decrease in APEC in the BAU scenario

Crude steel production¹



Final energy demand in iron & steel by fuel, APEC



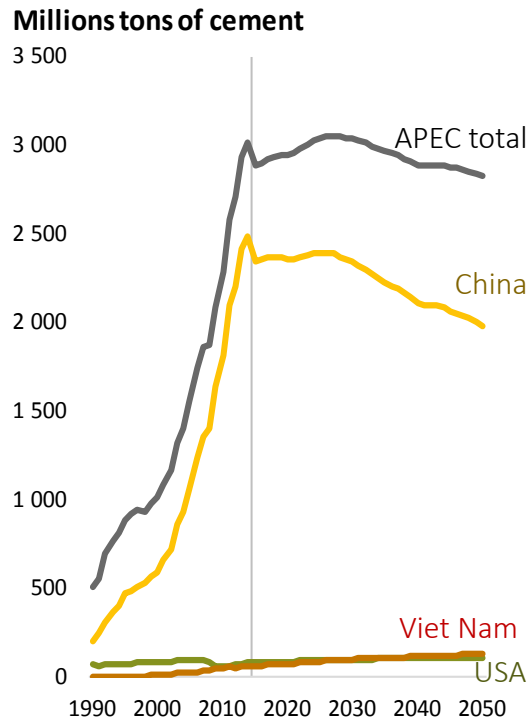
Decreasing production in China as well as gradual shifts to EAF² contribute to curbing energy consumption

Note1: The figure shows only selected economies. Economies shown in the figure are the three largest producers in APEC as of 2015.

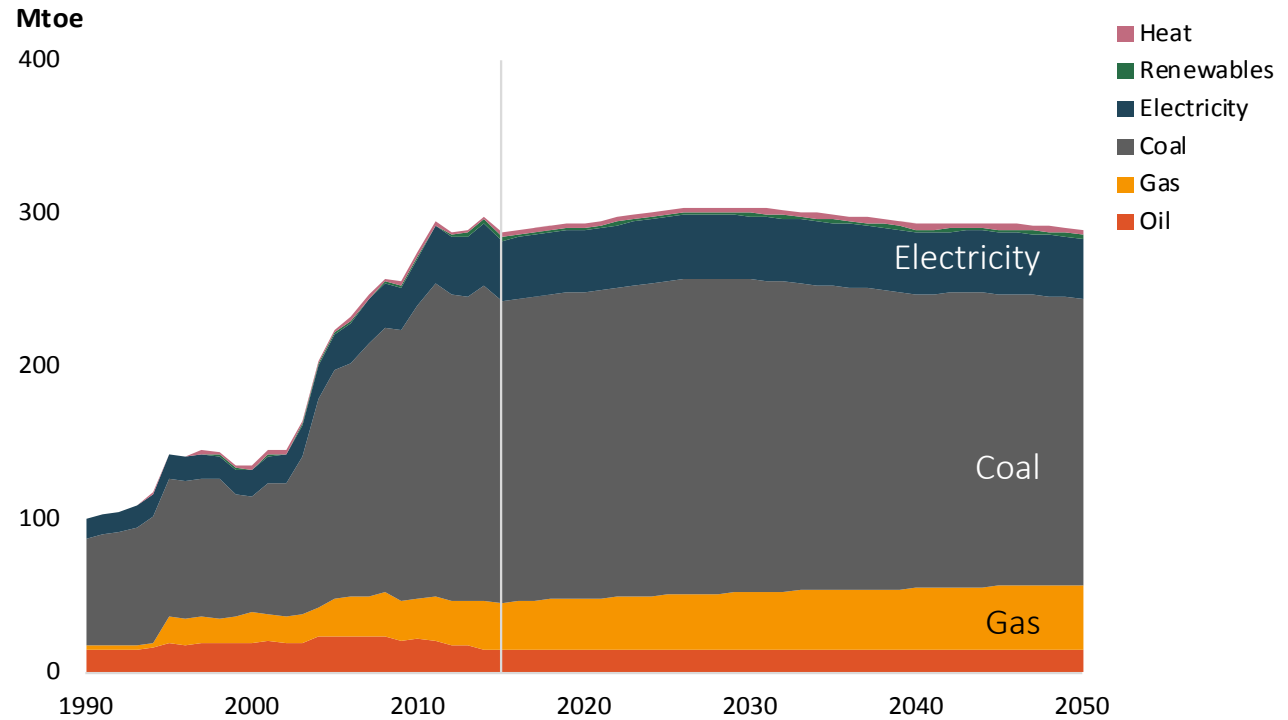
Note2: Electric Arc Furnace. Source: World Steel, APERC.

Non-metallic minerals (BAU): Cement production also peaks in the BAU

Cement production¹



Energy demand in non-metallic minerals by fuel, APEC



Construction boom in China is assumed to slow down.

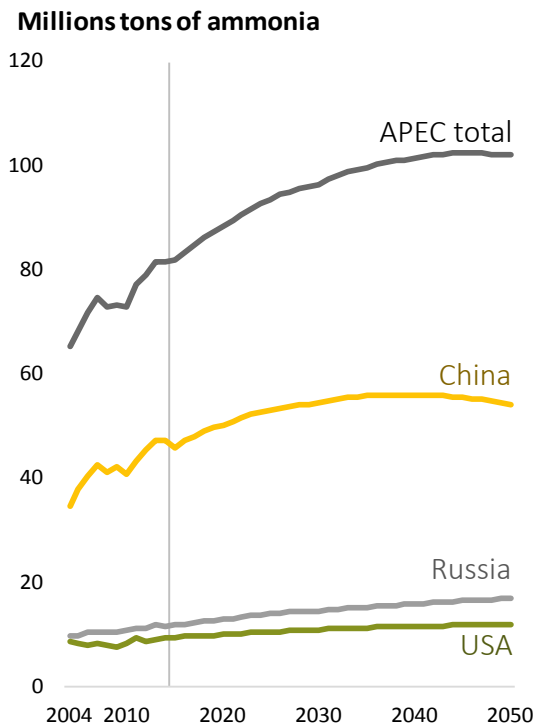
Coal remains the main energy source, although gas consumption grows (driven by gas-producing economies)

Note1: The figure shows only selected economies. Economies shown in the figure are the three largest producers in APEC as of 2015.

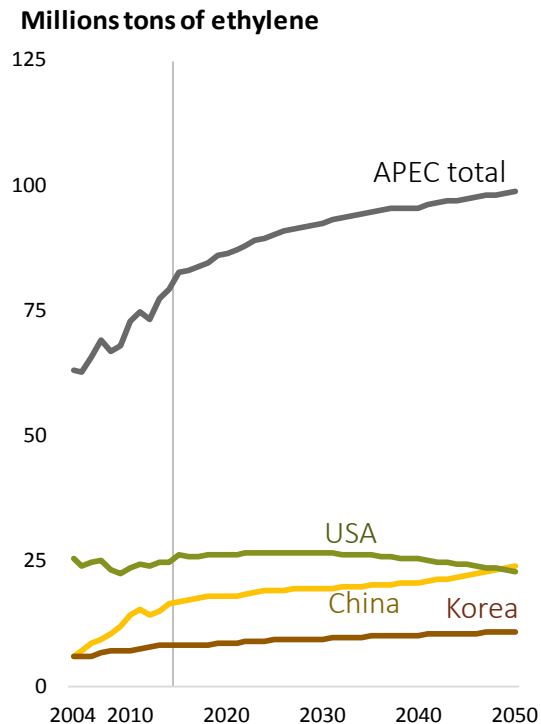
Source: USGS, APERC.

Projected rise in chemical production leads to rising energy demand in the BAU

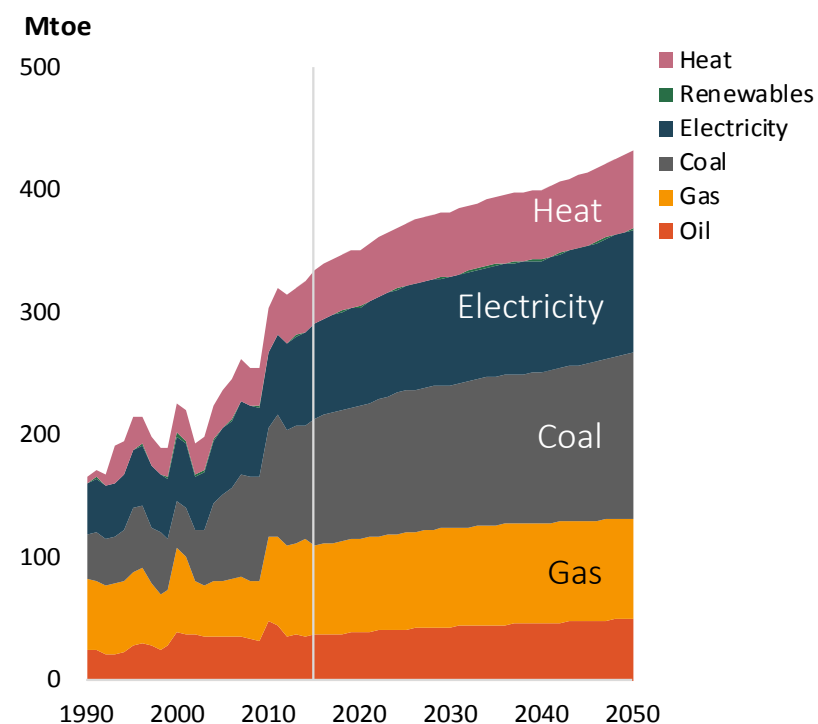
Ammonia production¹



Ethylene production¹



Energy demand by fuel, APEC



↑ Growth is driven by population (for ammonia) and continuous demand growth in emerging economies (for petrochemical products)

Note1: The figure shows only selected economies. Economies shown in the figure are the three largest producers in APEC as of 2015..

Source: USGS, METI, APERC.

Assumptions for the APEC Target (TGT) scenario:

The TGT assumes best available technologies for new capacity

Energy intensity of clinker production

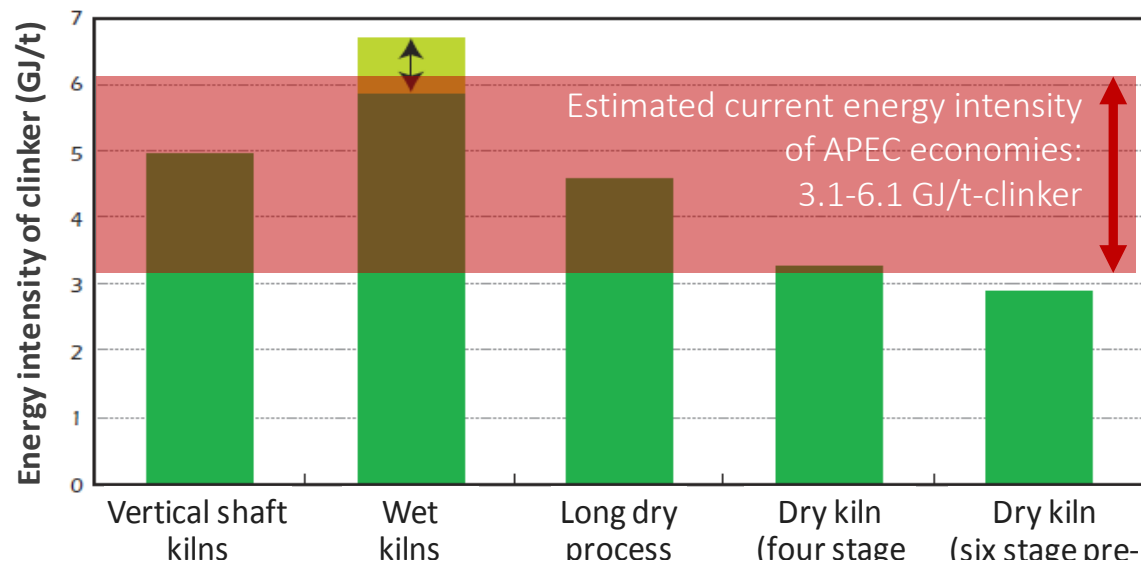
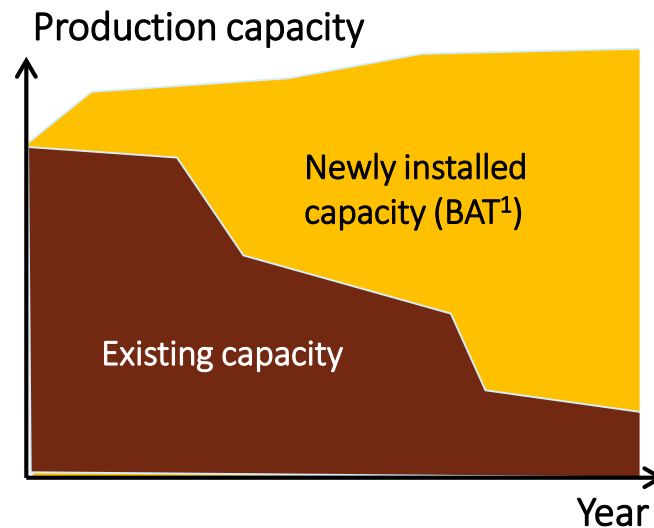


Image of capacity mix change



Existing technologies and sectoral energy intensity vary by economy

Sectoral energy intensity is assumed to improve through replacing existing capacity with BAT¹ facilities

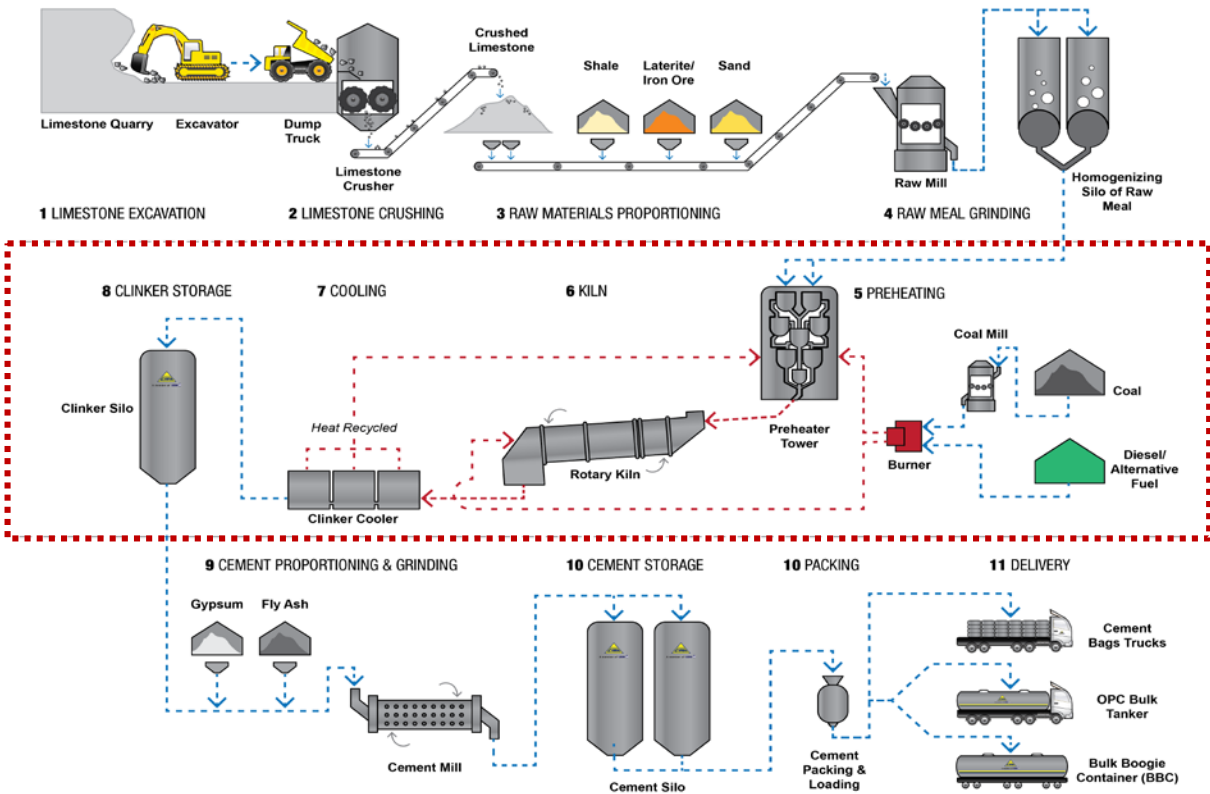
Note1: BAT=Best Available Technology

Source: IEA statistics, USGS.

Cement production process

Production process

Kiln consumes more than 99% of heat required for cement production



Clinker production
(calcination reactions, temperature: 1450°C)

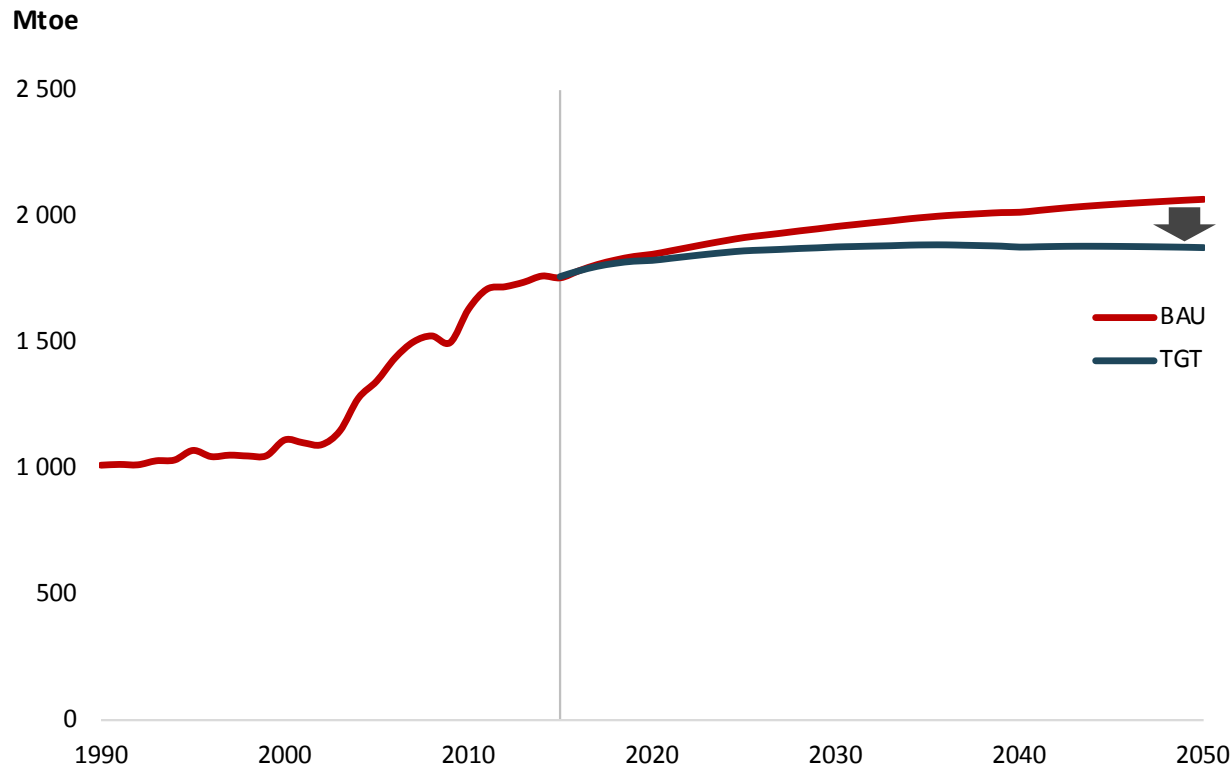


Picture from <http://www.cima.com.my/images/cementProcess.png>

Energy savings of 9% in the TGT scenario

Industry final energy demand, BAU and TGT

Energy savings of 9% in 2050 in the industry overall. Industry demand flattens around 2030



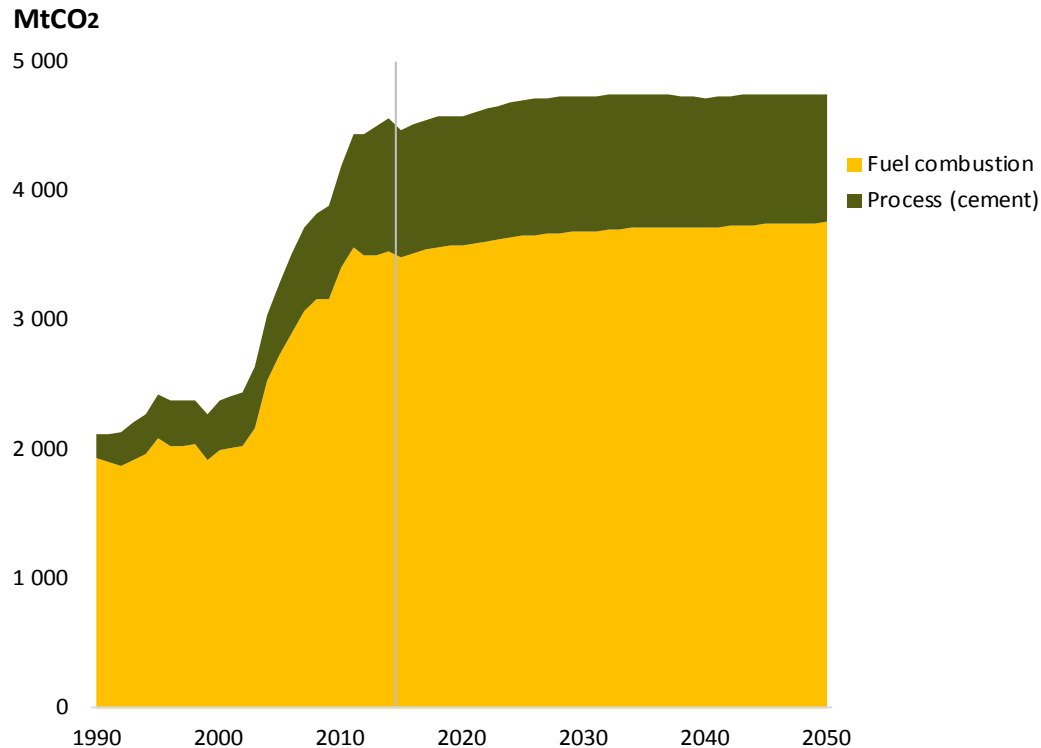
Savings in selected sub-sectors
(APEC total, 2050)

Iron & steel	15%
Cement	18%

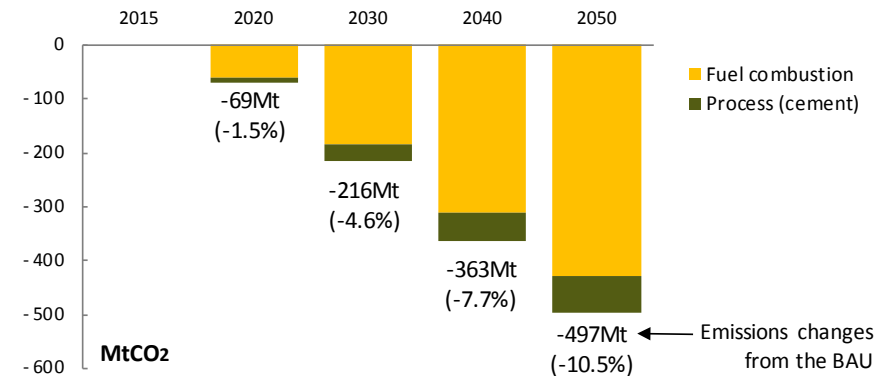
Source: APERC.

CO₂ emissions in the BAU and TGT

Emissions from the industry, BAU



Changes from the BAU to the TGT



Under the TGT, annual emissions can be reduced by about 497MtCO₂ in 2050, almost equivalent to the current energy-related emissions in Korea¹

Note1: Annual energy related CO₂ emissions in Korea was 568MtCO₂ in 2014

Source: APERC and IEA.

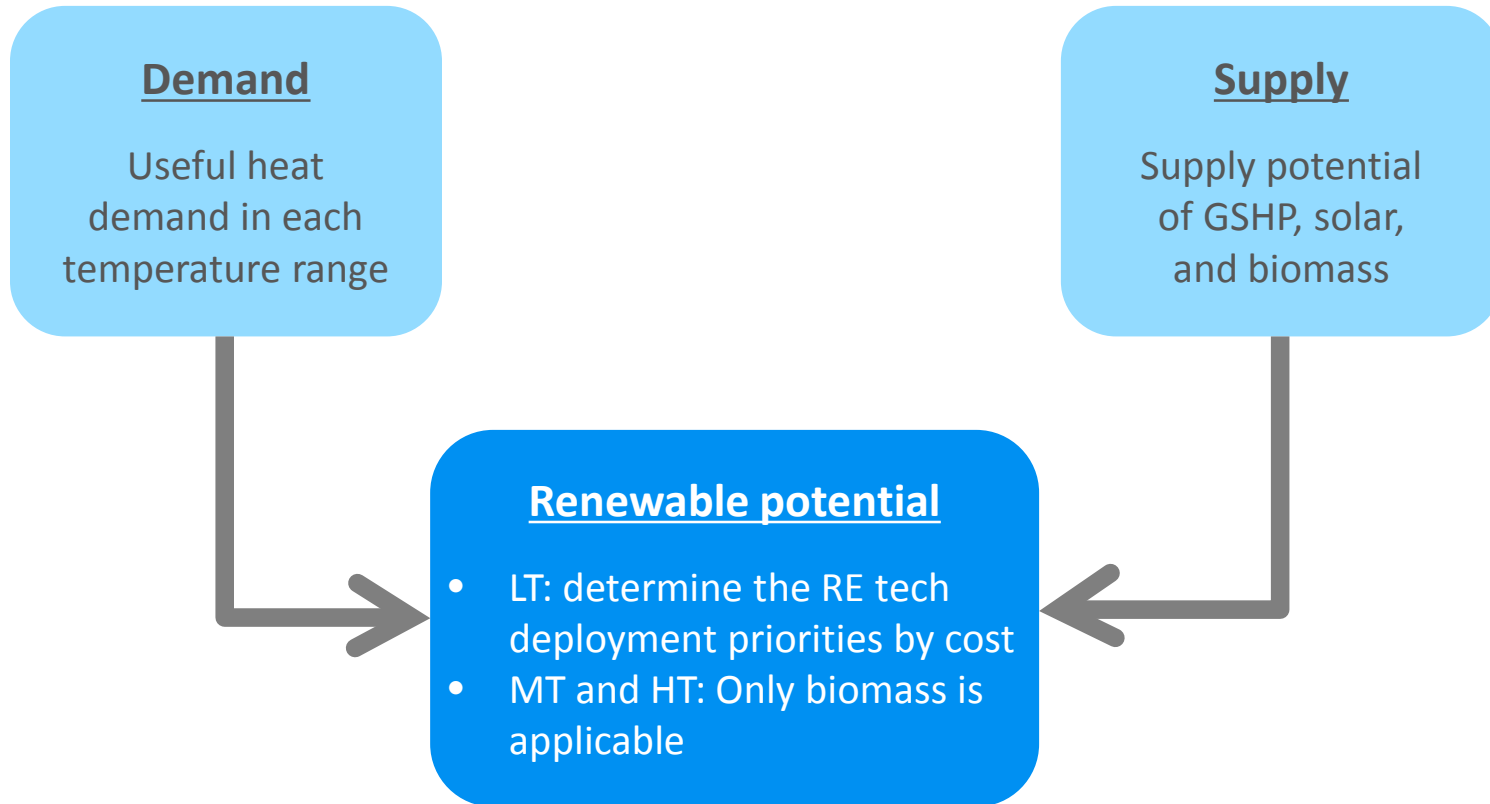
Conclusion and future work

- | APERC developed a tool to project industry activities on a physical-basis
- | Energy consumption in the iron & steel and cement sub-sectors in APEC is projected to decline due to saturated production (driven mainly by China)
- | The TGT scenario shows the opportunities for energy savings: 9% in the industry overall and 10%+ in both iron & steel and cement
- | Increasing efficiency leads to emissions reductions of about 500MtCO₂ in 2050 in the TGT compared to the BAU
- | Future work includes:
 - Outlook of renewable use in the TGT scenario (renewable potential estimation ongoing)
 - Two degree scenario projection—modeling of CCS in iron & steel and cement



Thank you for your attention!

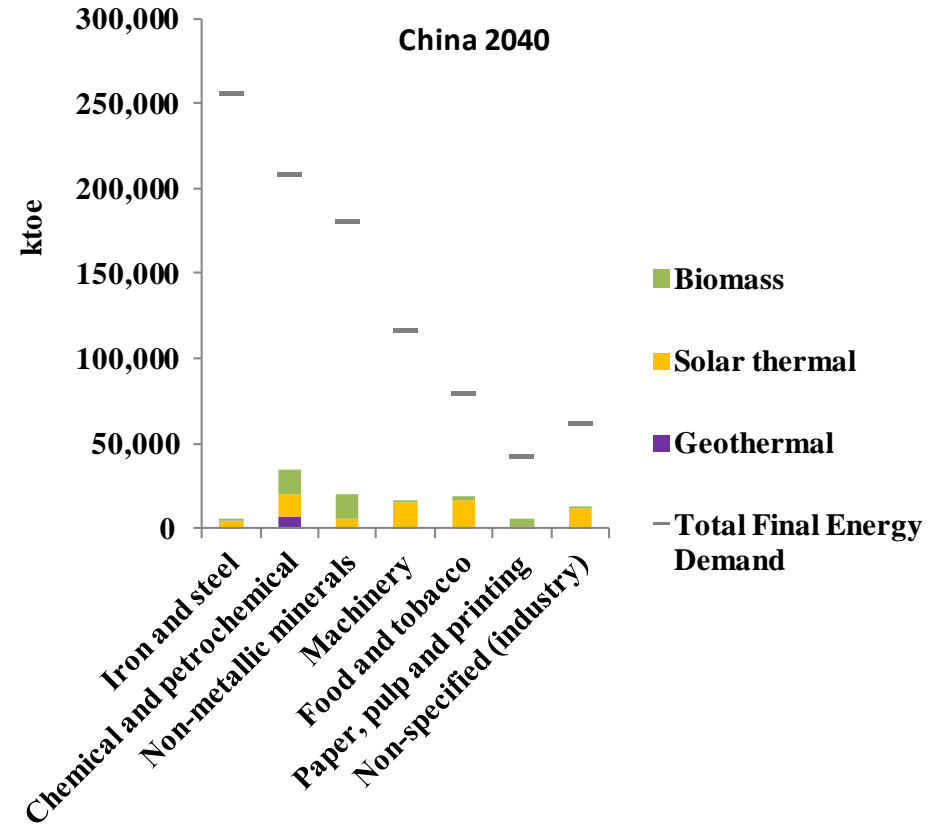
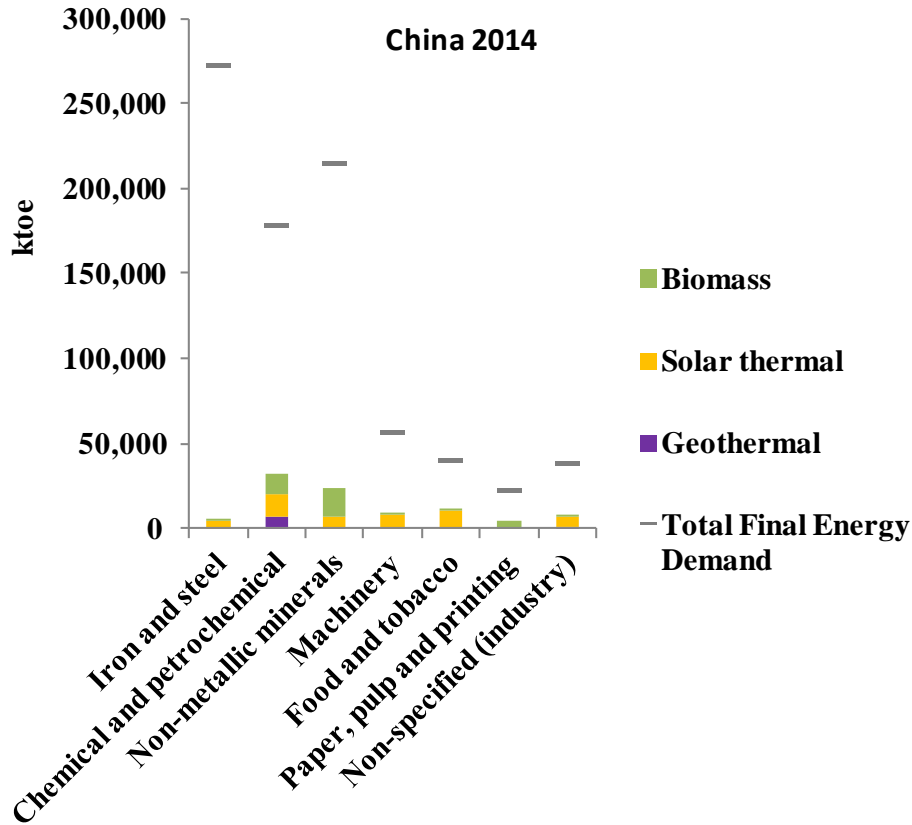
Modeling of renewable potential in the industry



Estimated the renewable utilization potential in each sub-sector with a consideration of useful heat demand (by temperature)

Note: GSHP=Geothermal heat pump; LT=Low Temperature; MT=Medium Temperature; and HT=High Temperature.

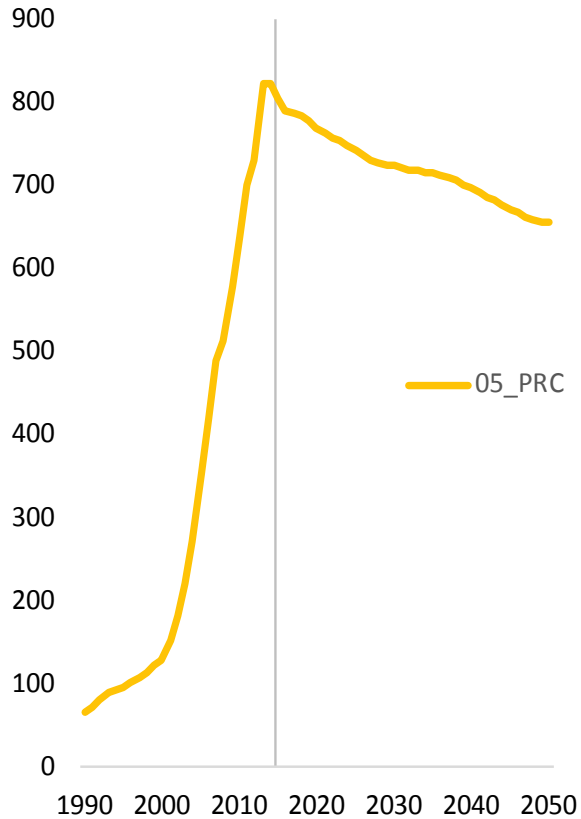
Renewable heat potential in selected industries in China



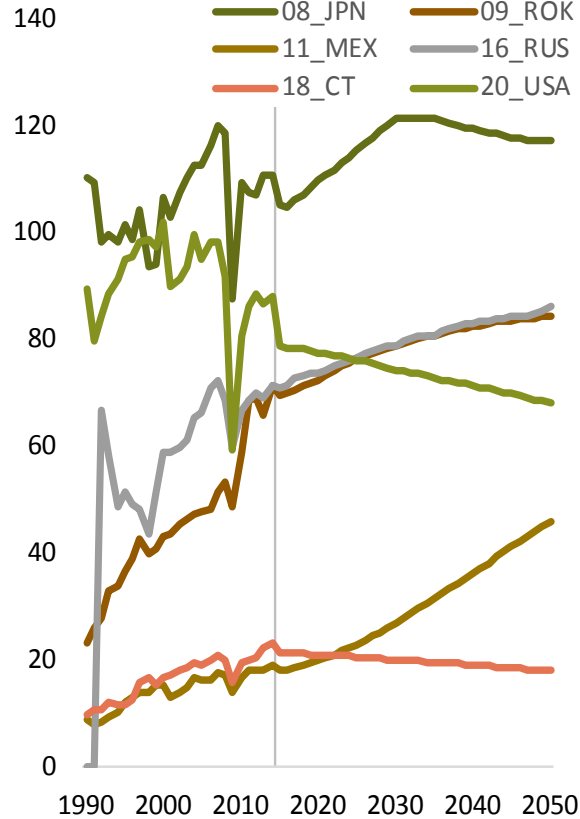
Note: Total final energy demand in these charts are obtained from the Outlook 6th edition.

Projection of crude steel production

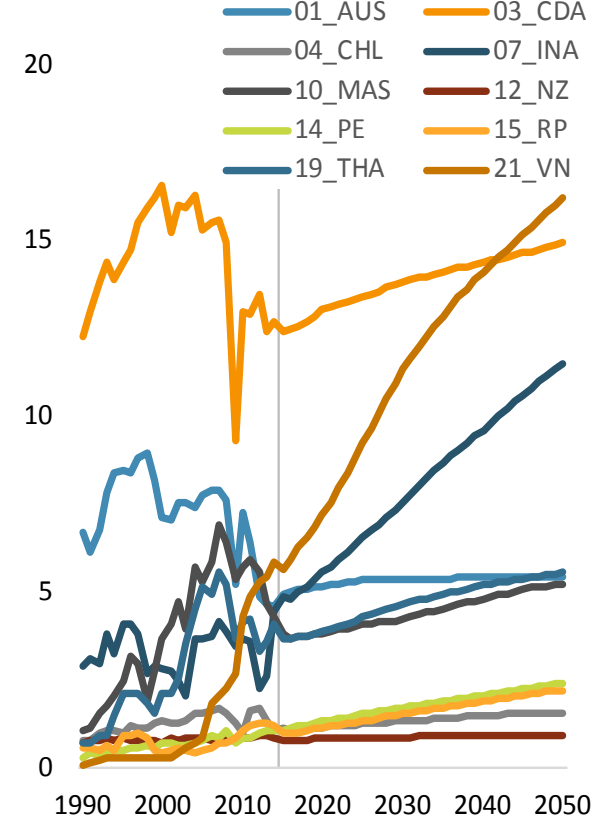
Millions tons of crude steel



Millions tons of crude steel



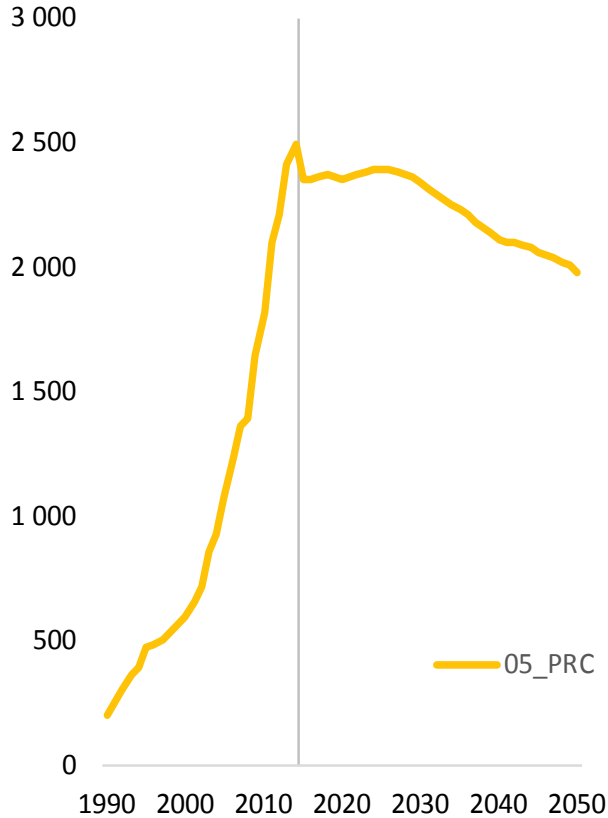
Millions tons of crude steel



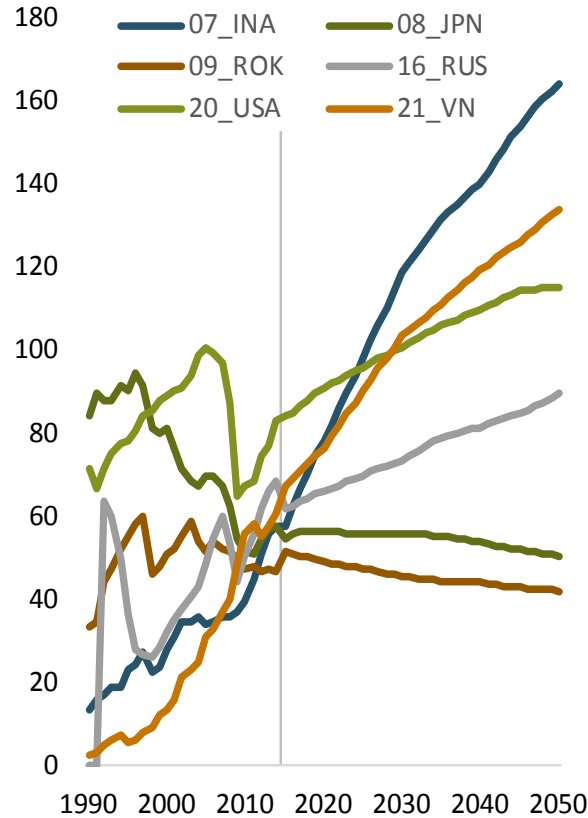
Note: Data for Russia are available after 1992.

Projection of cement production

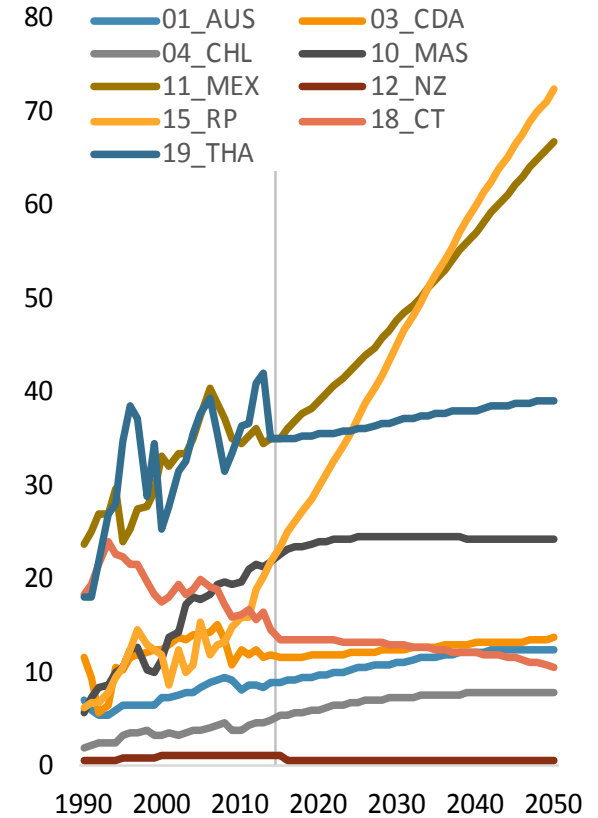
Millions tons of cement



Millions tons of cement



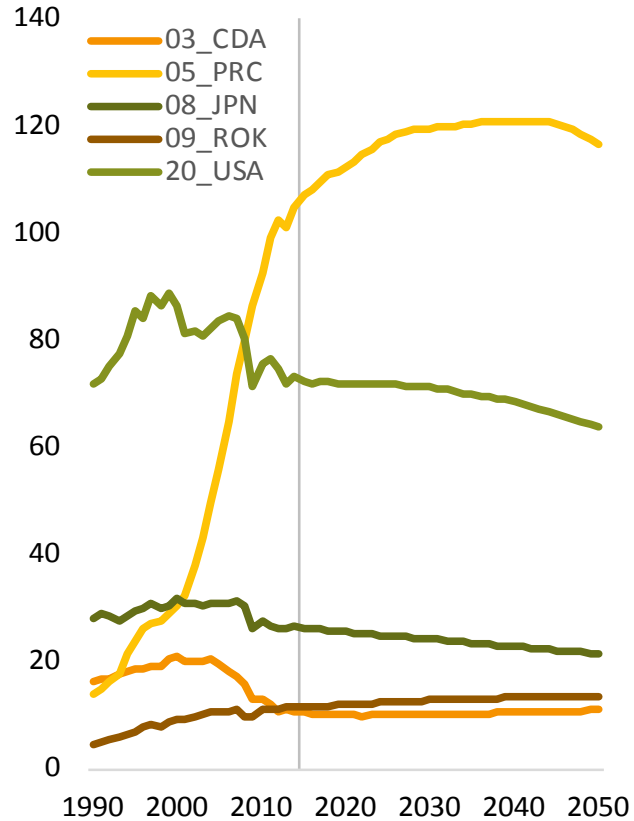
Millions tons of cement



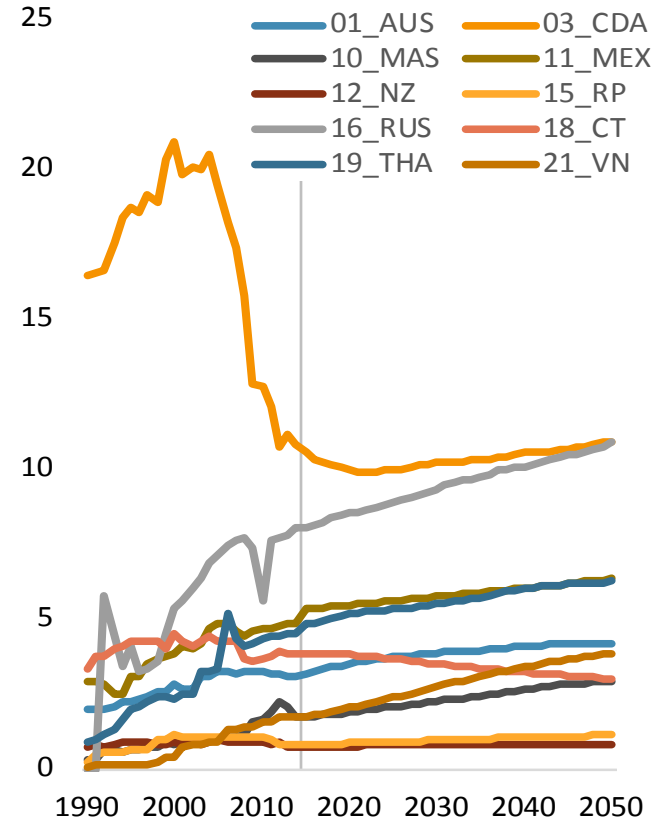
Note: Data for Russia are available after 1992.

Projection of paper and paperboard production

Millions tons of paper and paperboard



Millions tons of paper and paperboard



Note: Data for Russia are available after 1992.