Future megatrends and its impact on the sustainable development of the steel industry value chain

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World Steel Association

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  and raw material requirement
- Vision and agenda for a sustainable and resilient global steel industry

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Steel industry in the region

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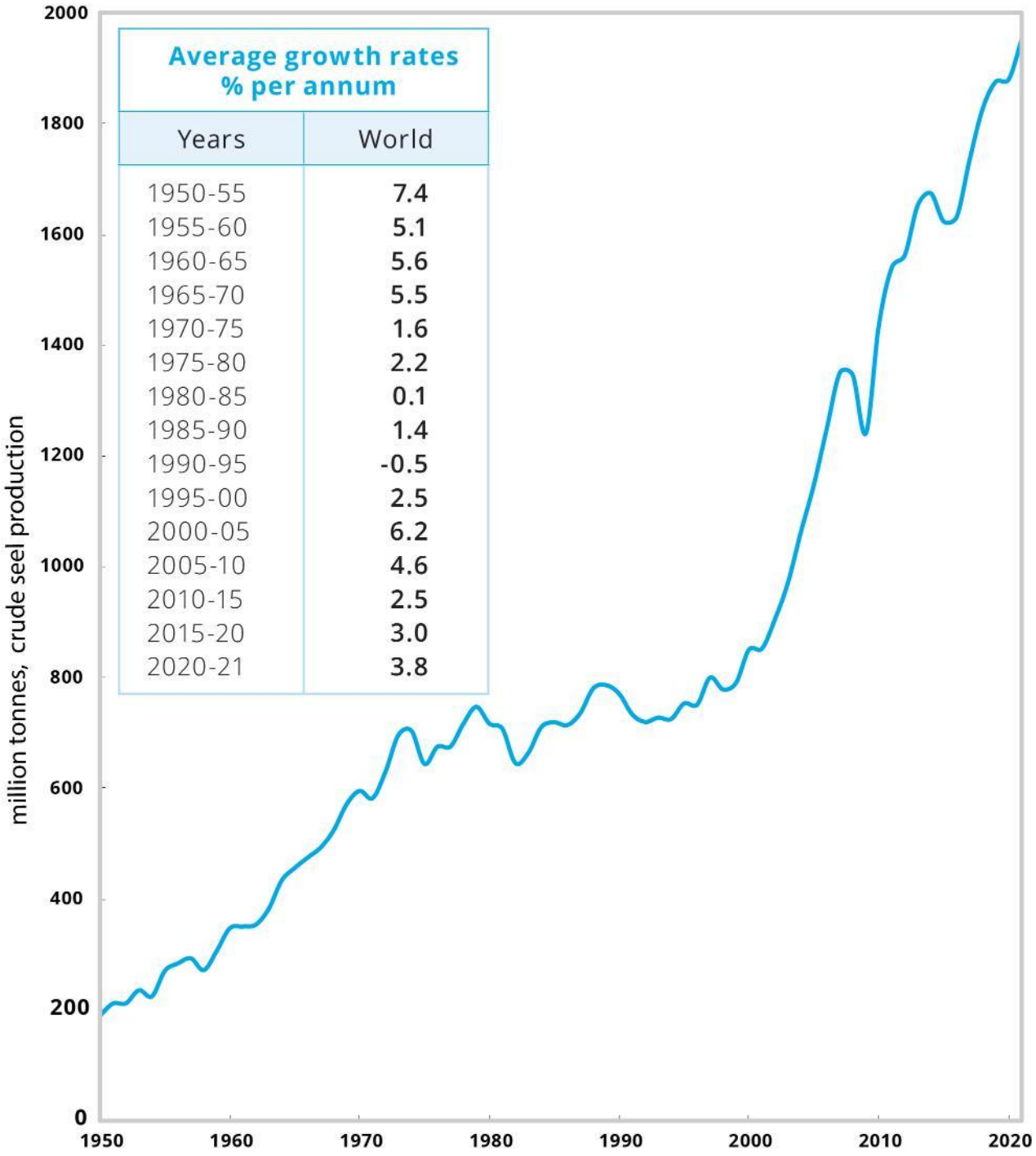
Steel production growth rate

- Global steel production has increased 10 times since the 1950s.
- Expectations are that growth will slow down in the decade ahead.



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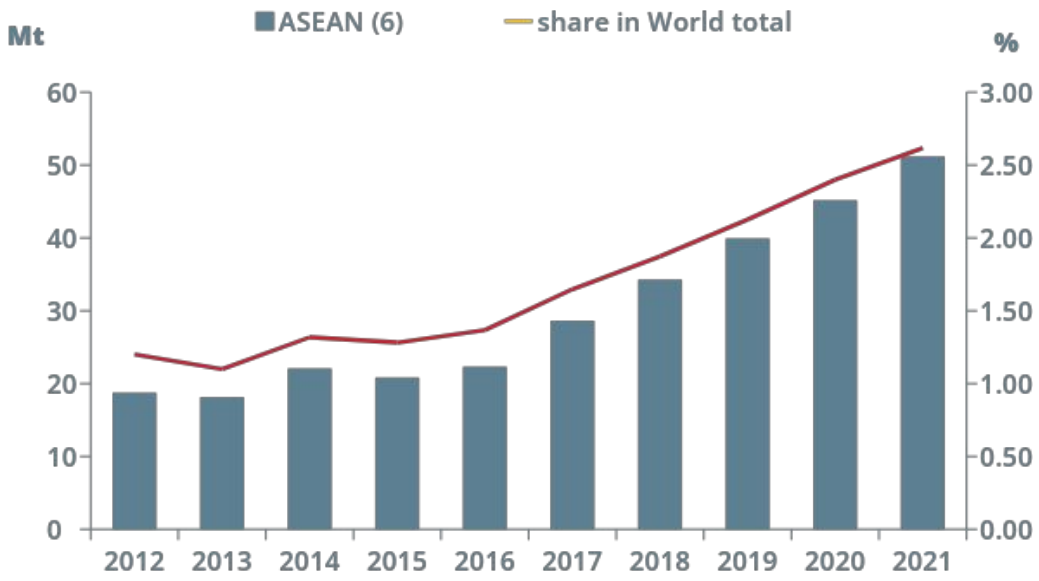
Production

Crude steel production in ASEAN (6) increased in last decade by 32 Mt, it is 2.7 times

At the same time, the region even faster increased pig iron production, reaching almost 23 Mt in 2021

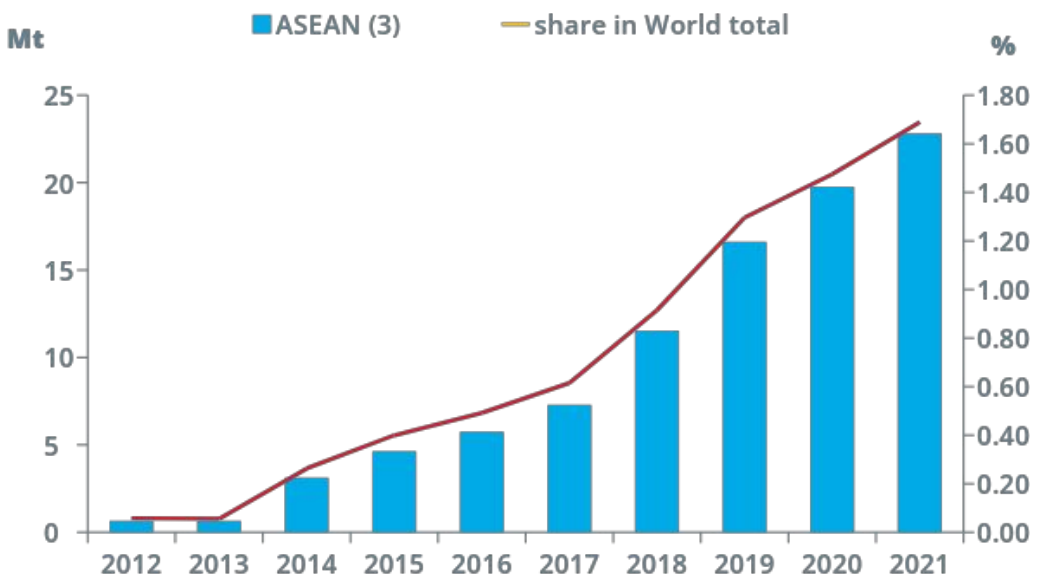
Crude steel production



Source: worldsteel

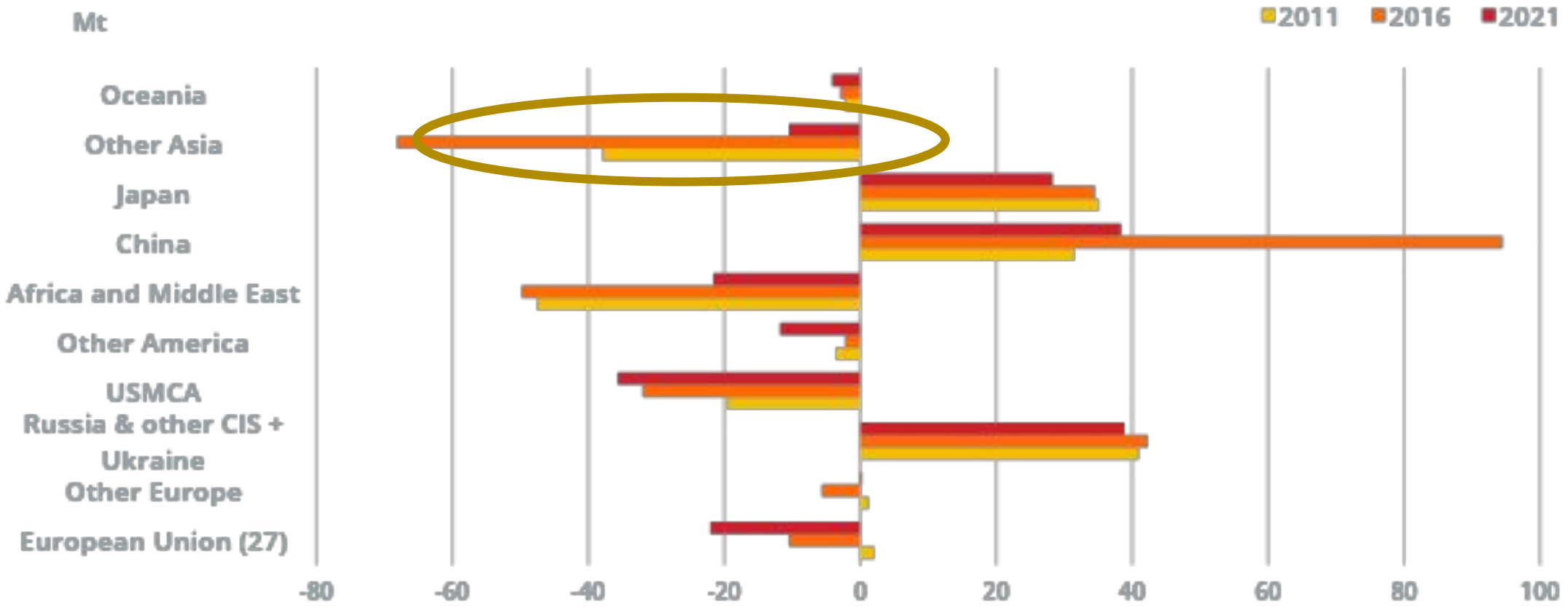
Note. ASEAN (6): Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam

Pig iron production



Note. ASEAN (3): Indonesia, Malaysia, Viet Nam

Steel trade, net exports, million tonnes



Source: worldsteel

Important trends to recognise

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Four megatrends accelerated after pandemic, triggering enormous changes

Climate Change

- Super megatrend constantly influencing all sectors

Technological Progress

- Address the issues such as carbon neutrality, wealth inequality and spreading disease

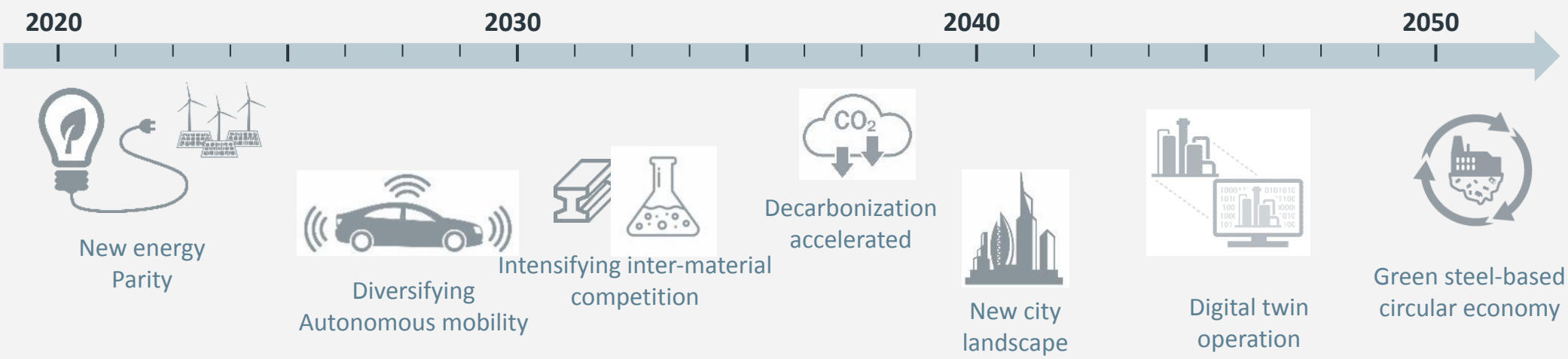
Socioeconomic Changes

- Demographic shift - Aging population, bigger role of new generations, shifting individual behaviors

Geopolitics

- Hegemonic competition to multi-polar world order & energy·tech divide

Innovation perspective — **Sustainability perspective**



How will the landscape change and what challenges will the steel industry face next 30 years?

Post-pandemic landscape of the globe

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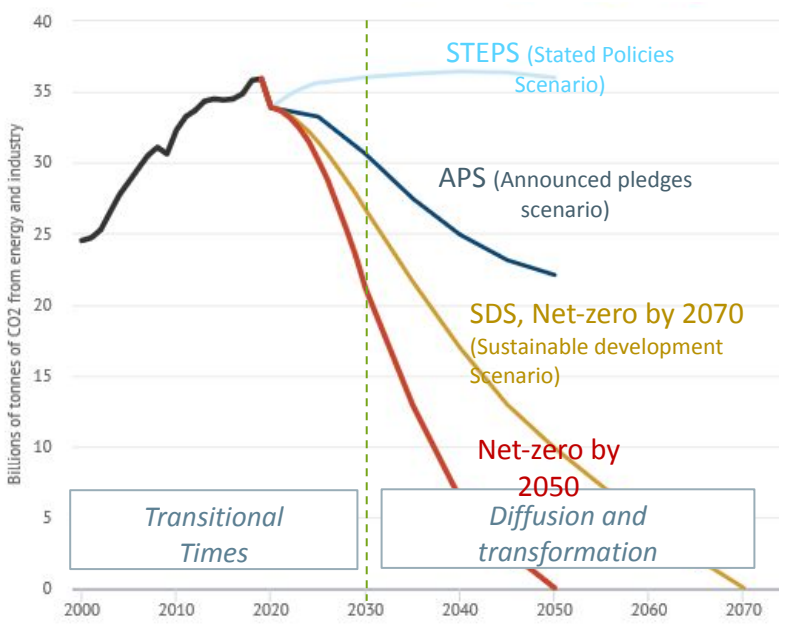
Climate change brings about changes to all sectors such as economy, society, politics, and technology

❖ Global net zero initiatives change not only economic and industrial structure, but also global technological standards and geopolitical hegemony

Global Decarbonization Pathways

Transitional times (2020~2030): Power decarbonization, innovative tech. development

Diffusion and transformation (~2050/70): Non-power decarbonization, clean e. & innovative tech. diffusion



Is Net-Zero Really Possible?

International society's net zero momentum by 2030 and clean energy infrastructure investment will determine success of net zero emissions by 2050

Pre-requisites and priorities for net zero

- Clean, reliable, and affordable energy supply
- Operations & supply chains decarbonization
- Net-zero buildings and urban infrastructure
- Zero emissions and smart mobility
- Global trade supporting climate actions
- Transition to a circular economy

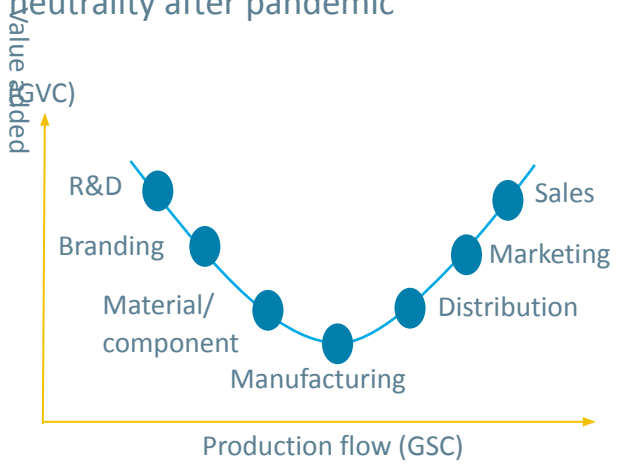
Source: IEA(2021), Net Zero by 2050, https://www.carbonbrief.org/iea-renewables-should-overtake-coal-within-five-years-to-secure-1-5c-goal/

Changes are expected in supply chain, carbon pricing and trade structure in the process of geopolitical rebalancing

- Rising uncertainty in transition to multi-polar world order (ex: US-China conflict, Russia-Ukraine war)
- Intensifying hegemonic competition for various issues like tech., environment and energy, beyond military & economic interest

① Security in supply chains

- Importance of stable sourcing of core tech. & components/parts growing bigger with heightened economic security and carbon neutrality after pandemic



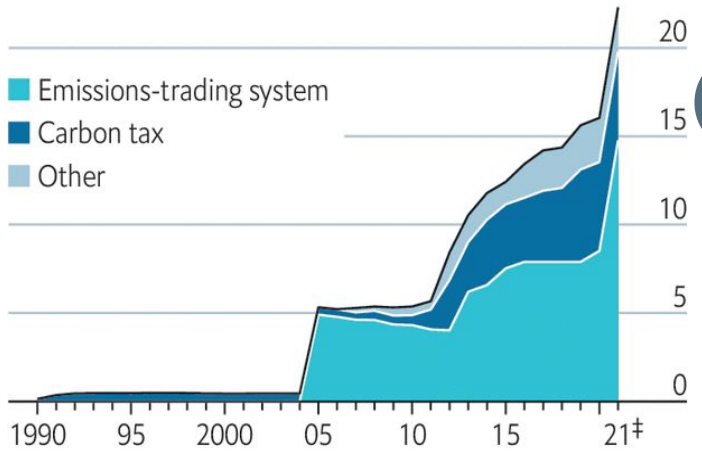
* Global value chain is value-added-led concept, global supply chain is supply/production flow-led concept

② Expanded impact of carbon pricing

- Cross-border measures (ex. CBAM) in line with adoption of carbon tax & ETS

Carbon-pricing initiatives

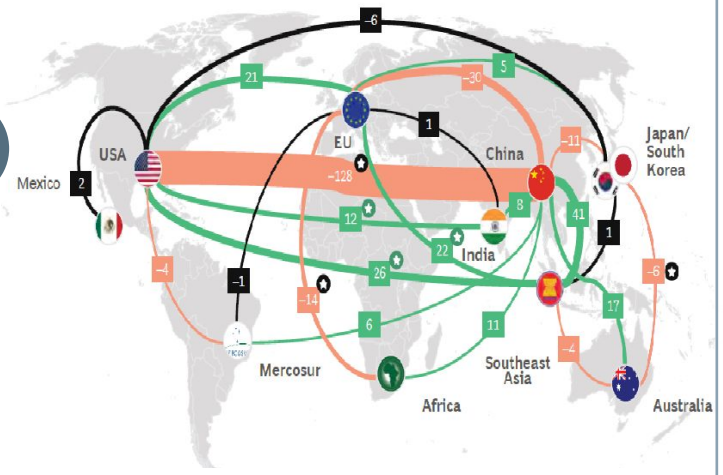
(% of annual global greenhouse-gas emissions covered)



23% as of '21

③ Structural change in global trade

- Contracted global trade with changing supply chains, but robust intra-trade



<-3%
-3~3%
>3%

- Color of arrow represents percentage change from 2019~2023F
- Width of arrow represents volume change in trade flows 2019~2023F

Source: KIEP(2021), World Bank(2022), BCG(2020)

Future of steelmaking technology and raw material requirement

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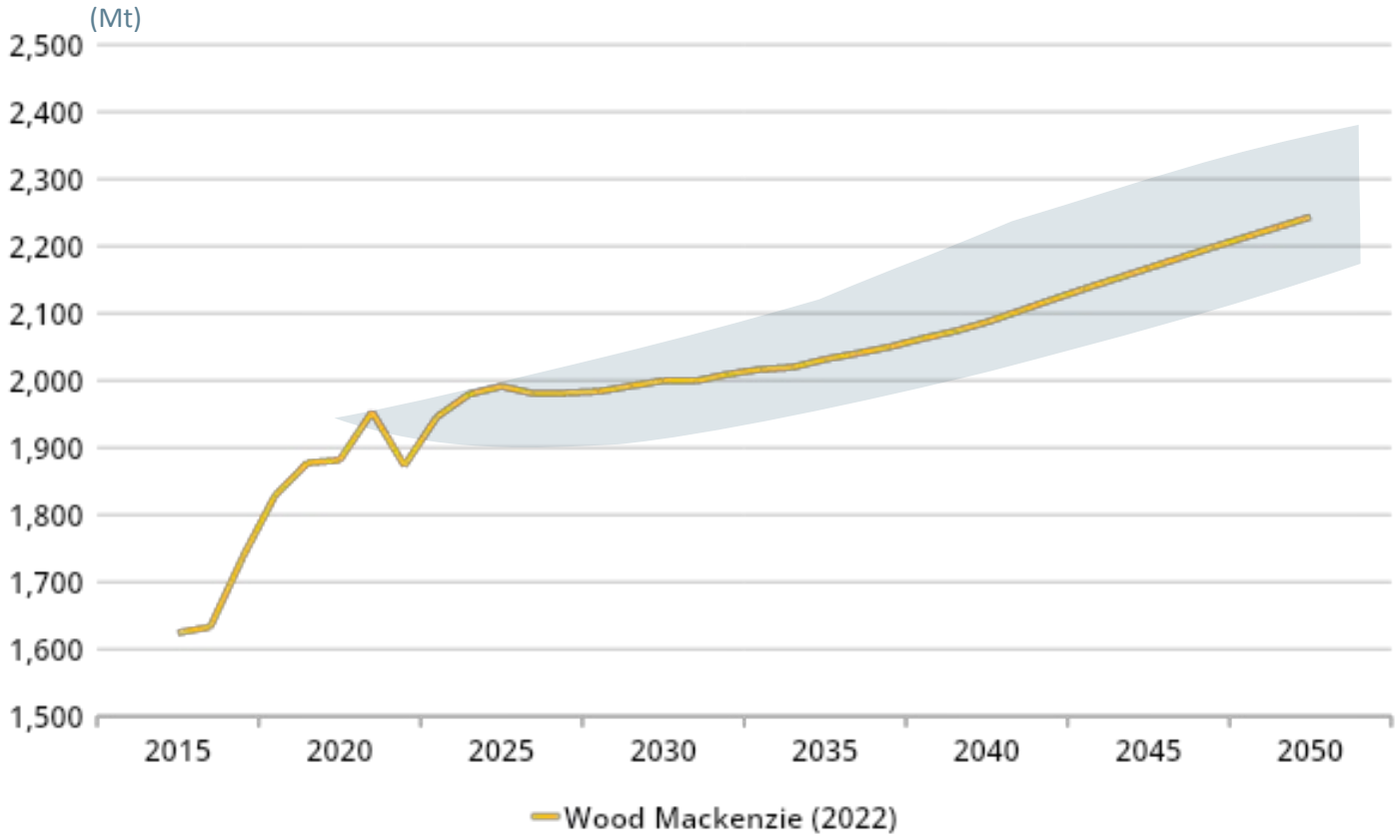
Long-term global steel production required to meet both market needs and carbon reduction

- Despite carbon neutrality trend, crude steel production to reach 2.2-2.4 bil. tonnes by '50 with modest growth of steel demand
- Liable to reduce carbon emissions required by a society despite production increase

[Global crude steel production forecast]



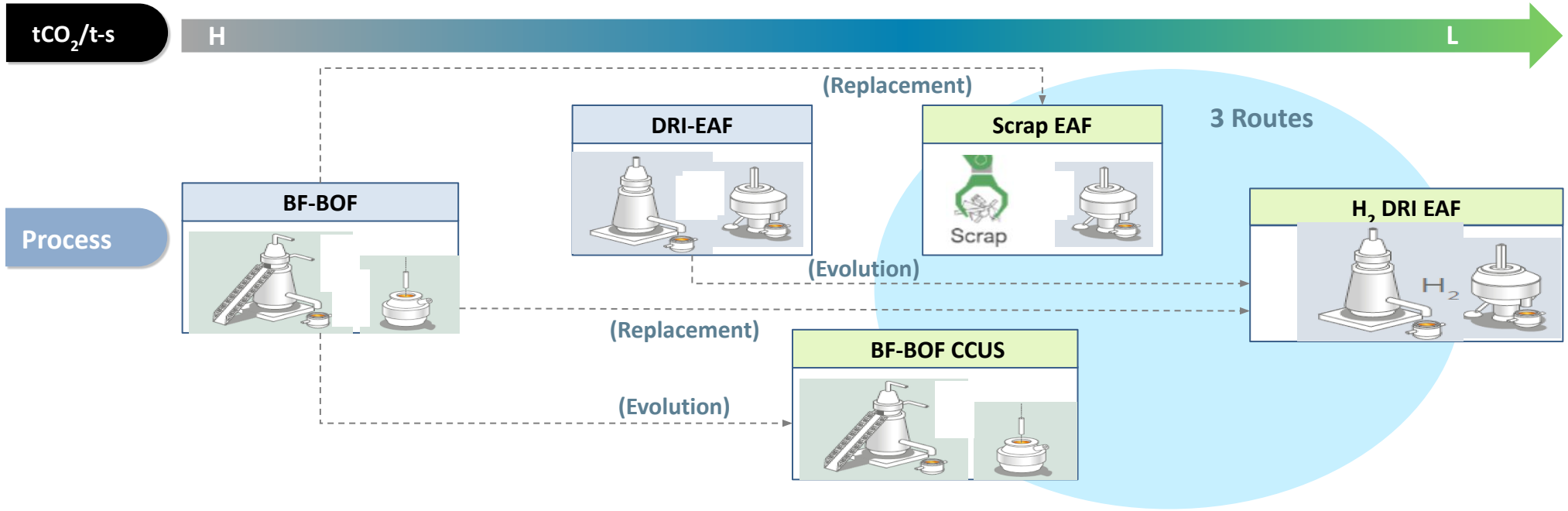
Source : Wood Mackenzie('22.6.)

Global crude steel production ('20-'50)

- **Various institutions :** Project modest growth of about 1% annually next 30 years to 2.2-2.4 billion tonnes in '50. China's crude steel production to peak between '20~ '30
- **Wood Mackenzie** : Forecasts China's crude steel production peaking in '20 to reach 804 Mt in '50 under zero carbon initiative ('70), and India and SEA's production replacing China's after '40

3 routes of steelmaking process to promote carbon neutrality

- Carbon reduction method by timeline : Process optimization (~'30) → Carbon reduction (~'50) → Carbon neutral ('50~)
- Cost advantage is the top priority for steel industry → Future competitiveness to be determined by low-cost sourcing of raw materials & energy and high energy efficiency of facilities



	BF-BOF	DRI-EAF	BF-BOF CCUS	Scrap EAF	H_2 DRI EAF
KSF	**Facilities going bigger and consolidated**	**Natural gas procurement cost**	**Economic feasibility for CCUS tech.** (power use, capture rate)	**Scrap sourcing cost, thin-slab casting & rolling**	**Green energy procurement, operation efficiency, & unit scale-up**
Future issues (Competitive edge)	Carbon tax, Coal price volatility	Carbon tax, NG price volatility	Commercial feasibility, CO_2 removal rate	Stable supply of renewable E., Limit in high-end steel quality	Stable supply of DR pellet, Limit in 100% H_2 operations

Steel as a key material to the transition to a circular economy

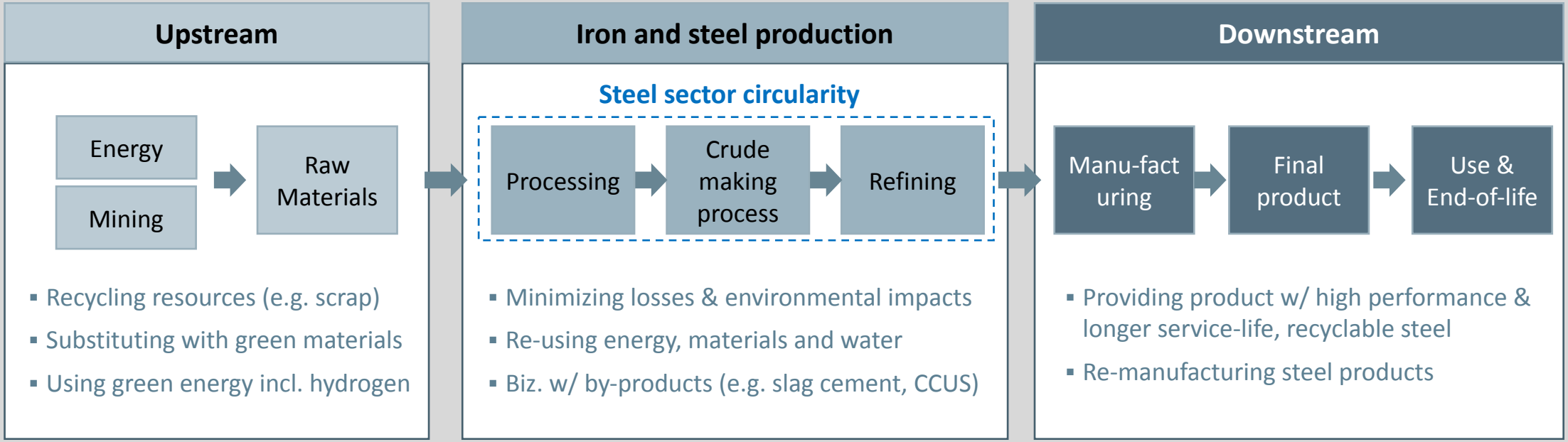
AS-IS

- **Linear Economy**: Natural resources are turned into products that are ultimately destined to become waste. This process is summarized by "**take, make, waste**".

TO-BE

- **Circular Economy**: Creating a closed-loop economic system that involves the process of '**reuse, remanufacturing, recycling and reduce**' in pursuit of no waste

The circular economy and the steel industry value chain



Future of urban development

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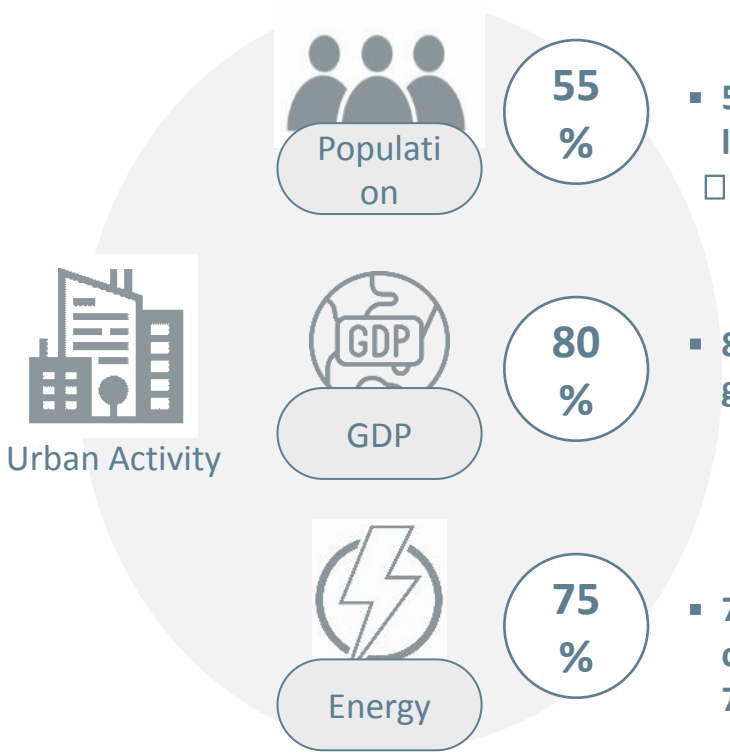
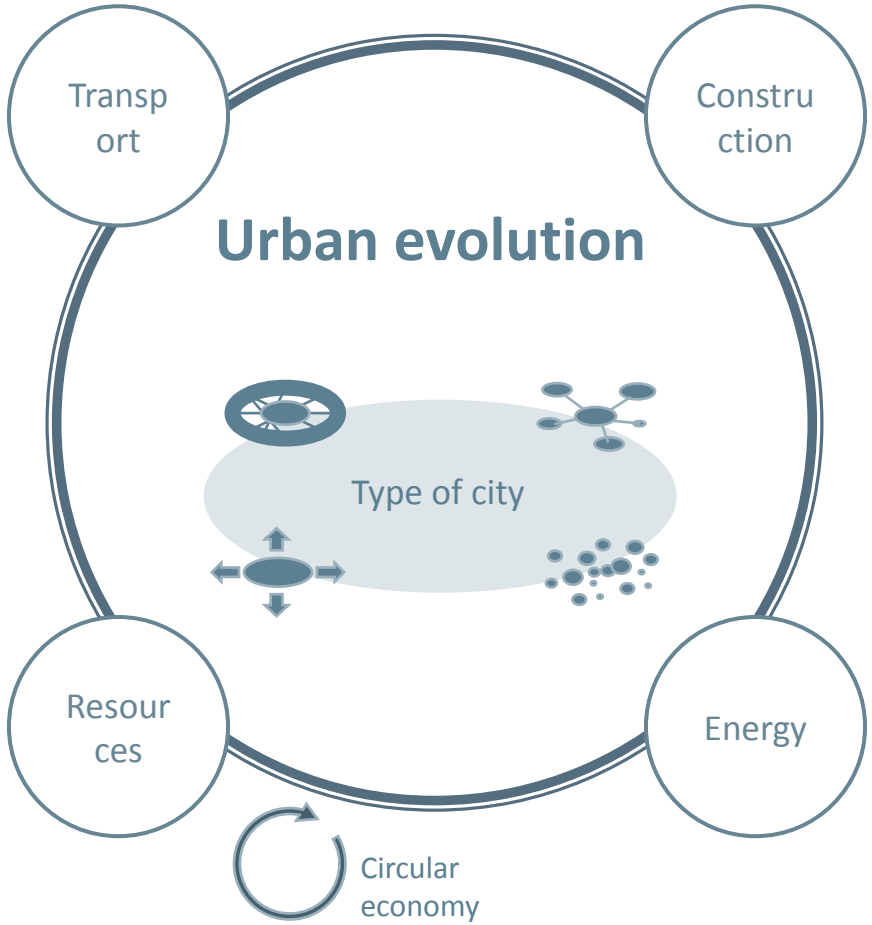
Why cities are important?

A city is a hub where energy, materials and infra. are utilized and interconnected with each other through mobility, logistics, and networks



- **55% of global population live in cities (‘21)**
  - **68% (‘50)**
- **80% of global GDP generated in cities**
- **75% of final energy consumption and 70% of CO_2 emissions**



Source: UN, World Bank Urban Development

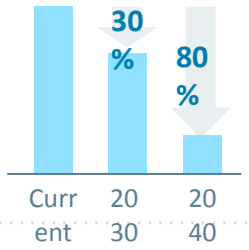
Differentiated changes in construction, mobility, and energy landscape are expected in each city archetype

Advanced Metropolises

- High Income
- High-density

New York

New York's CO_2 emissions goal



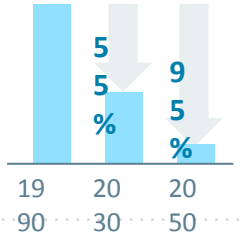
- 20% energy cut from public bldgs., high efficient design for new skyscrapers
- Fossil fuels prohibited in mega construction (2035)
- Sustainable mobility (walk, bicycle, public transport) above 80% (2050)

Prosperous low-density cities

- High Income
- Low-density

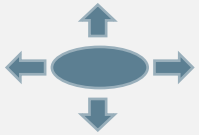
Amsterdam

Amsterdam's CO_2 emissions goal



- Polycentric transition of cities with eco-friendly urban center
- Zero-carbon land and sea freight within 10 years
- Transition to a "Circular-City" by 2050, re-circulation of all consumption resources

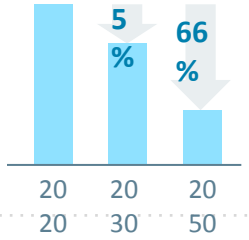
Expanding monocentric cities



- Low Income
- High-density

Beijing

Beijing's CO_2 emissions goal



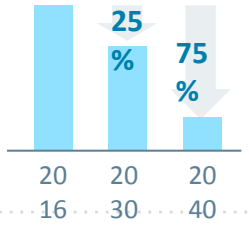
- 2060 carbon neutral plan (Xi Jinping in UN General Assembly, Sept. '20)
- 'Energy Revolution' for carbon neutrality
- Plants relocated outside Beijing, whereas product design, SW/AI industry will gather in the city center

Developing Scattered cities

- Low Income
- Low-density

Johannesburg

Joburg's CO_2 emissions goal



- Carbon neutral by '50, ease of high carbon intensity
- Land use diversity, narrowing of divide, encouraging social mix
- Green conservation, biodiversity protection, sustainable city

* The detailed information of each city planning roadmap for 2050 is provided in the appendices

Future construction, mobility & energy landscape differ by city archetypes

Type of city	Advanced Metropolises	Prosperous low-density cities	Expanding mono-centric cities	Developing scattered cities
	✔ New York, London, Paris, Hong Kong	✔ SF, Amsterdam, Brussels, Bonn	✔ Beijing, Bangkok, Mumbai, Istanbul	✔ Johannesburg, Manila, Rio de Janeiro
Construction	• High density city and low density suburb	• Infra, network planed first & developed later	• High rise, high density city (compact, efficient land use)	• Low rise cheap housing, unmanaged development
Mobility	• Public transport + private car (intra-city connectivity)	• Public transport+ active mobility	• Public transport such as bus and taxi	• Poor public transport access (intercity bus)
Energy	• Complex power grid system	• Independent, dispersed energy production & consumption	• Compact energy consumption for residential and commercial buildings	• Obsolete grid system, insufficient power system

Pattern of steel use differ by city type – steel use saturates in developed cities whereas construction, mobility and energy material hike in developing cities

Advanced metropolis

London, Barcelona, Berlin, Boston, Chicago, Frankfurt, Hamburg, Helsinki, Hong Kong, Houston, Los Angeles, Madrid, New York, Seoul, Singapore, Tokyo, Stockholm, Manchester, Nagoya

Prosperous low-density cities

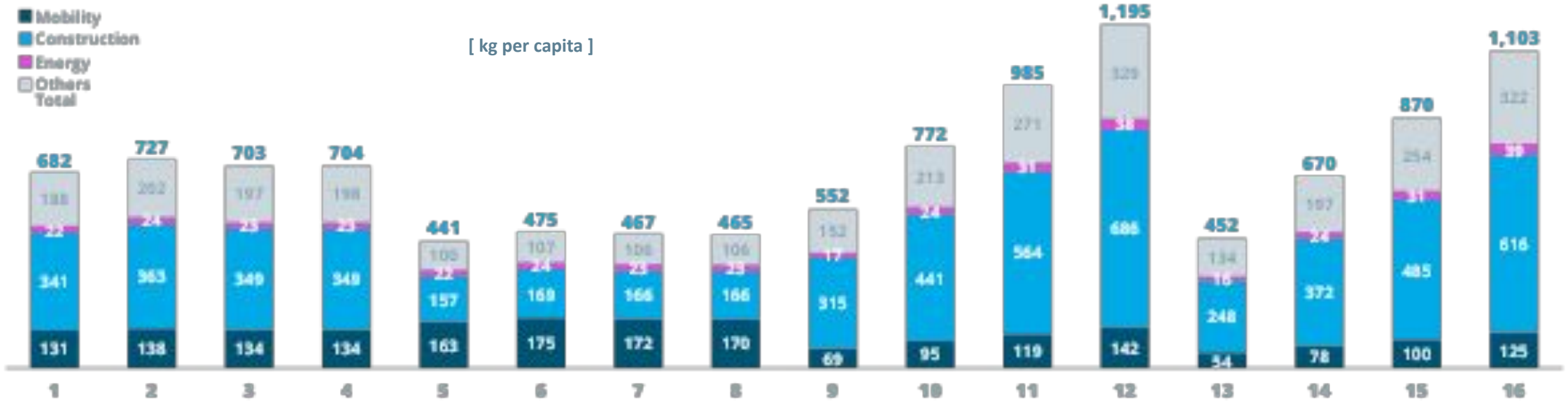
Amsterdam, Osaka, San Francisco, Sydney, Bonn, Dresden

Expending mono-centric cities

Bangkok, Beijing, Guangzhou, Kolkata, Mumbai, Rio de Janeiro, Sao Paulo, Tianjin, Shanghai

Developing scattered cities

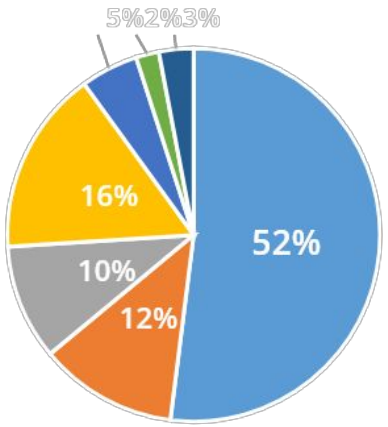
Jakarta, Johannesburg, Shenzhen



* A model using worldsteel's apparent steel use forecast data, country-sector distribution proportional to GRDP(Gross Regional Domestic Product)

Construction uses more than half of global steel, but the current steel market share in construction is still low

Steel use by industry
(Global steel use 1,768 Mt)



- Building and Infrastructure
- Automotive
- Metal products
- Mechnical equipment
- Other transfort
- Domestic appliances
- Electrical equipment

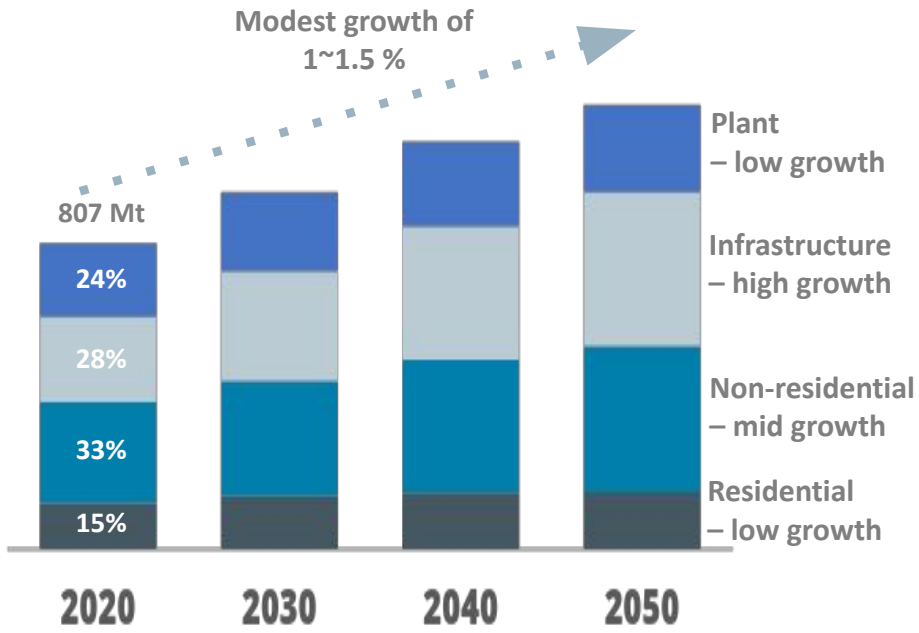
Construction market segment and its market size (% of total)		Steel market share within each market (% of total)	Segment contribution to steel market share (% of total)
Building (70%)	Residential (40%)	10%	4.00
	Commercial & Business (15%)	40%	6.00
	Industry (15%)	60%	9.00
Infrastructure (30%)	Bridge (5%)	20%	1.00
	Road (10%)	5%	0.50
	Railway (5%)	40%	2.00
	Airport (3%)	15%	0.45
	Port (7%)	25%	1.75
		Steel market share in global construction industry	24.70

Source: worldsteel, “The Opportunity of Constructsteel” (2022 POSCO Forum), modified by POSRI

Steel demand for construction still to grow with its eco-friendliness and easy composition w/ other materials, though competing w/ concrete and future materials

❖ Trends in modular building design, digital 3D construction, and growing infrastructure(in particular, the construction of super long bridges and high-speed railways) with high steel intensity points to continuous growth in steel use in construction

[Steel demand potential by construction type (Mt)]



Steel demand growth depending on construction growth & steel intensity

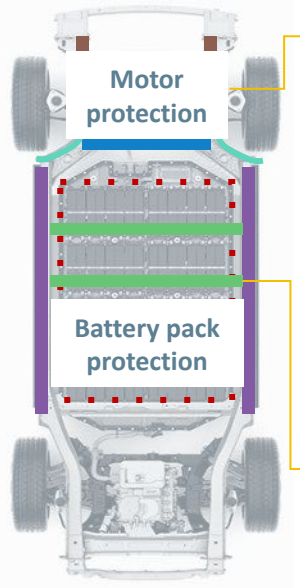
(vs. average)	Residential	Non-residential	Infra.	Plant
Steel intensity	Low	High	High	High
Construction growth	Low	Mid	High	Low
Steel demand growth	Low	Mid	High	Low

Source: IHS Markit (Construction investment), worldsteel (Steel), POSRI forecast

Despite fierce competition for light-weight materials, steel maintaining strong advantage with its clean process, recyclability and economic features

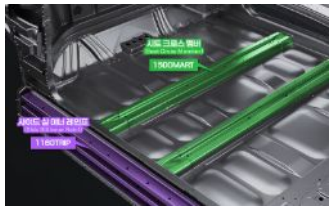
Reinforcement through electrification

✔ **Reinforcement to protect battery pack & motor**
- Hot power fusion (HPF), aluminum profile



▪ **Forward collision avoidance**

✔ Side member to protect motor, front side rail to dash reinforcement to protect battery and seats

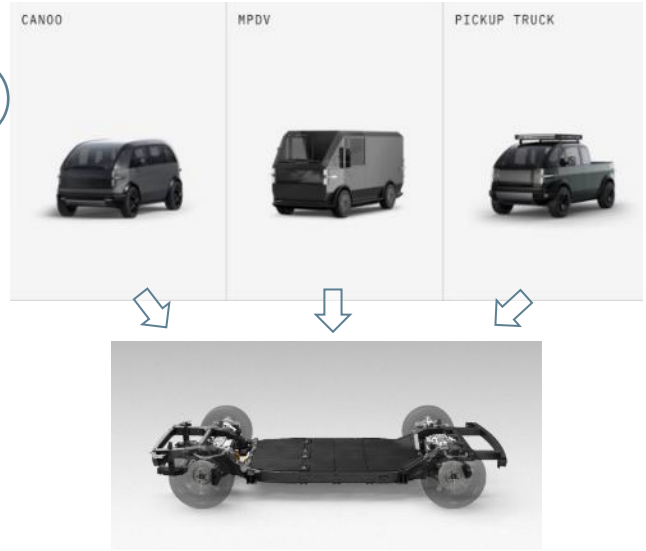


▪ **Battery pack protection**

✔ Side seal reinforcement for side collision, cross member reinforcement to hold up the flooring and prevent torsion

Change by modular design

✔ **Platform for purpose built vehicle (PBV)**
- Various PBVs on common platform
- Autonomous shuttle & robot taxi platform
- Ladder frame for SUVs & pickup truck



Automotive materials future

✔ **Material diversification**
- Steel taking upper hand with rising importance of clean process and recycling
- Rising share of light-weight materials

【 Steel demand for the automotive sector, mil. tonnes 】

2020	2030	2040
164	210	219

Source : POSRI forecast

【 Carbon emission per material kg, CO_2-kg/material-kg】

Fe	Aluminum	CFRP
2.3	8.9~16.5	15~22

Source : Aluminum Association('13), worldsteel('10), Nikkei auto

Lightweight material portion (of aluminum and plastics) may rise as EVs and AVs need longer range

Steel still stays as a mainstream material as it has superior cost competitiveness with lower carbon footprint and recyclability

Vision and agenda for a sustainable and resilient global steel industry

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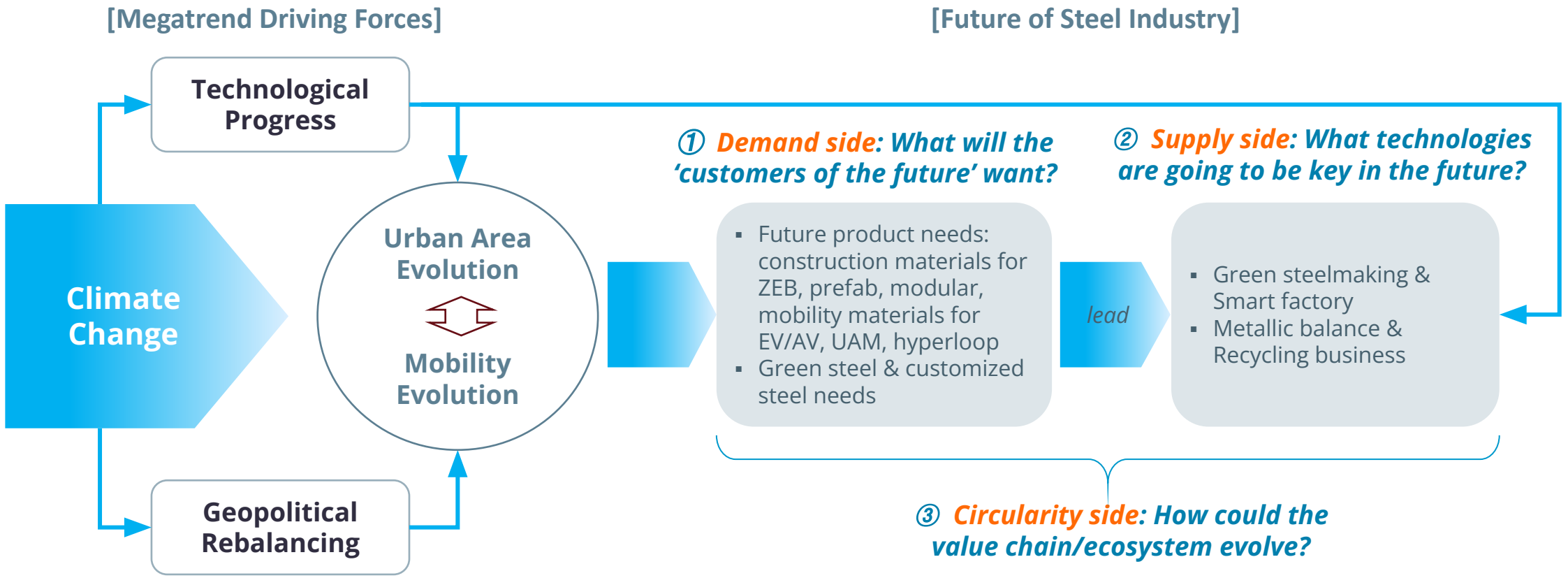
How steel business will thrive under rapidly changing urban area and mobility landscape?

Sustainable and resilient steelmaker: Eco-friendly and digital producer of smart, green and customized solutions



If you have any comment and suggestion on this presentation, please feel free to send an e-mail to Dr. Jun H. Goh (‘jgoh@posri.re.kr’) or Dr. Baris Ciftci (‘Ciftci@worldsteel.org’).

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