

Legal Statement

The purpose of the information in this presentation is to guide ICA programs and provide members information to make independent business decisions.

All projections in this presentation are prepared by Warren Centre from publically available market information.



Antitrust Guidelines

ANTITRUST GUIDELINES FOR COPPER INDUSTRY TRADE ASSOCIATION MEETINGS

The following guidelines with respect to compliance with antitrust laws of the United States, Japan and European Community¹ are intended to govern the conduct of participants in copper industry trade association meetings, both at the meeting itself and in informal discussions before or after the formal meeting.

Price. Competitors should not discuss future prices (including terms of sale) of their products. There is no blanket prohibition against the mention of or reference to current or past prices but limits must be observed. Such references or mentions should occur only when necessary in connection with the development of association programs. For example, reference to a particular price level in comparing the cost of a copper product to a competing product is permitted. Whenever possible, such references should be discussed in advance with legal counsel.

Competitive Information. Competitors should not discuss the market share of a particular copper producer or copper fabricator's products. Furthermore, nothing should be said at a meeting which could be interpreted as suggesting prearranged market shares for such products or producer production levels. The overall market share of copper products may be discussed with regard to competition with non-copper products and general market acceptance.

New Products. Competitors should not encourage or discourage the introduction of a new product by another competitor or reveal a particular copper company's plans to change the production rate of an existing product or to introduce a new product. No company should disclose to another company whether it is in a position to make or market a new product. New products may be discussed in a technical manner or from the standpoints of competition with non-copper products and general market acceptance. In addition, proposed methods for and results of field and laboratory testing can be considered.

The Role of Legal Counsel. Legal counsel attends association meetings to advise association staff and other meeting attendees regarding the antitrust laws and to see that none of the matters discussed or materials distributed raise even the appearance of antitrust improprieties. During the course of a meeting, if counsel believes that the discussion is turning to a sensitive or inappropriate subject, counsel will express that belief and request that the attendees return the discussion to a less sensitive area.

A paper entitled
"Copper Industry Trade Associations and the Antitrust Laws"
is available upon request.

10/92, 5/93, 10/10

¹ Other foreign competition laws apply to International Copper Association, Ltd. (ICA)'s activities worldwide.



THE WARREN CENTRE



Copper Technology Roadmap 2030

Asia's growing appetite for copper

Ashley Brinson, Executive Director

The Warren Centre for Advanced Engineering, 28Oct2016

About the Warren Centre

- The Warren Centre for Advanced Engineering, established 1983
- Affiliated with the Faculty of Engineering & IT, University of Sydney
- Enduring themes:
 - Stimulate the application and development of new engineering technology
 - Encourage innovation
 - Develop Australia's public policy → wealth creation, high quality of life
 - Independent comment and advice to government and industry
- *Building Construction Technology Roadmap, 2004,*
Copper Development Centre Australia



Translating technology and innovation



"Planes, Trains and Automobiles: How innovation is changing everything"

Panel discussion on transport, Australian Stock Exchange, Feb 2016



Technology Roadmap 2030

Summary Findings

Major Trends	Impact on Cu Demand
1. Demographic <ul style="list-style-type: none"> Major population and economic growth 	Residential/Appliances 10.4MT Infrastructure
2. Electricity <ul style="list-style-type: none"> Move to renewables and decentralisation 	<ul style="list-style-type: none"> Solar PV 6.5MT Wind 3.6MT
3. Transport <ul style="list-style-type: none"> Move to electric and autonomous vehicles 	<ul style="list-style-type: none"> Light vehicles 6.4MT Electric Rail 1.5MT Electric Buses 1.5MT
4. Decarbonisation <ul style="list-style-type: none"> Paris COP21 	<ul style="list-style-type: none"> Substitution towards renewables Accelerating electrification Continue economy of scale



Methodology: Copper Roadmap 2030

- 2004 Building Construction Technology Roadmap
- Research: peer journals; UN, World Bank, US EIA
- Paris Climate Conference (COP-21): Nov 30 – Dec 12, 2015
- Interviews: academics, thought leaders, economists, law
- Interviews: ICA Asia/NY experts
- Synthesis and Internal “debate”



Scope of the study

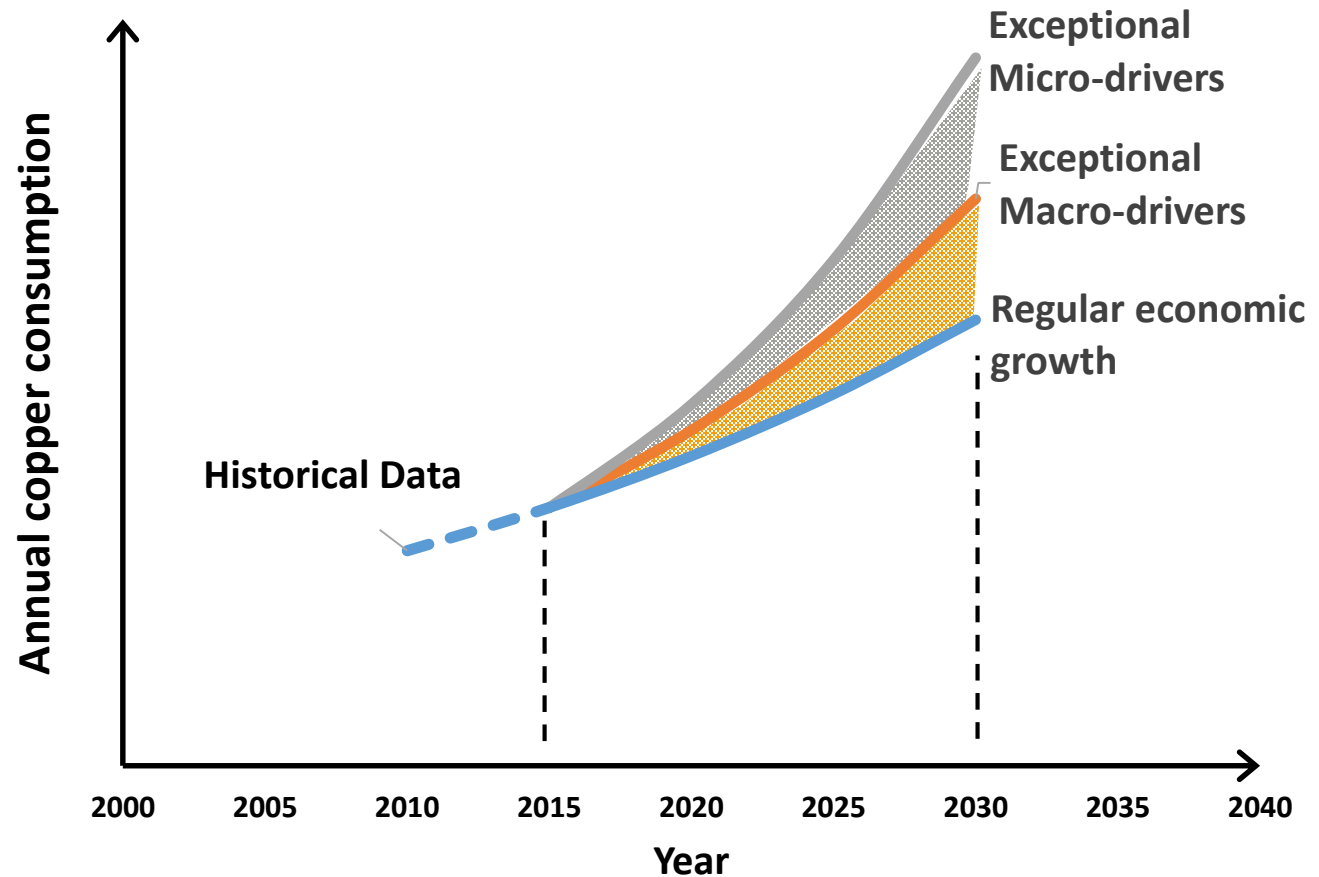
- Geographic boundaries, time to 2030
- Focus 1: Demographics
- Major technology trends
 - Focus 2: Electricity
 - Focus 3: Transportation
 - Focus 4: Decarbonisation



Interpreting the report

Not estimate of Asia copper market size

- Macro-driver
 - 1. Demographics
- Technologies: mixed macro- and micro-drivers
 - 2. Electricity
 - 3. Transport
- Pure micro-driver
 - 4. Decarbonisation substitution
- Figures are cumulative 2015 to 2030 effect





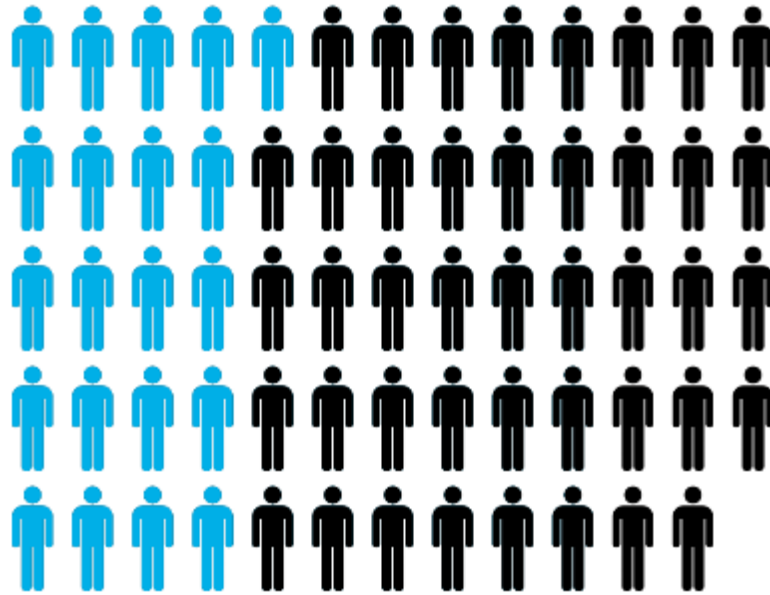
Focus 1: Demographics, GDP indicators, policy


1. Demographic indicators to 2030:

India → major rise in population and urbanisation

India 2015

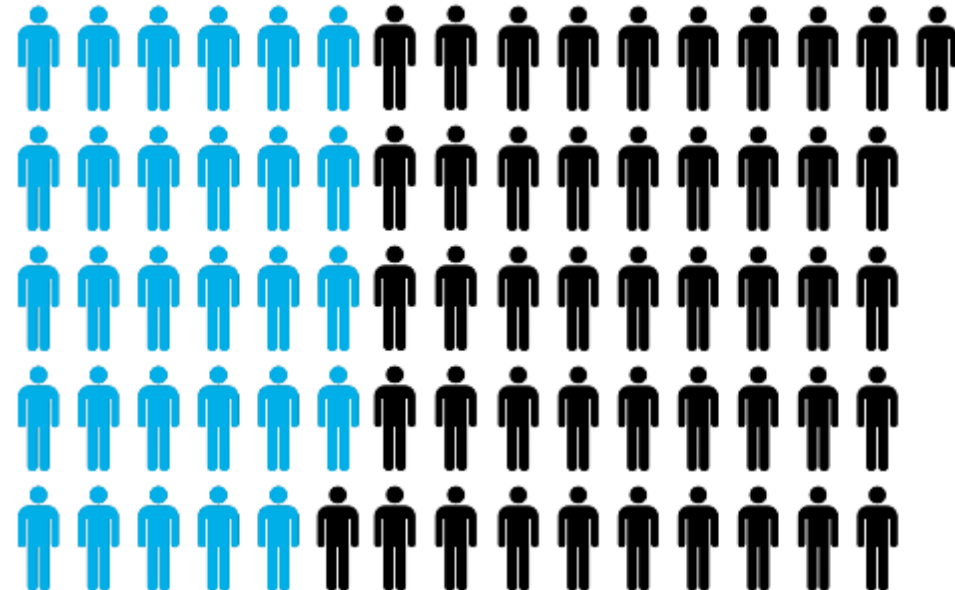
Population (everyone): 1.31 billion
 Urban population (blue): 420 million



 = 20m people

India 2030

Population (everyone): 1.53 billion
 Urban population (blue): 583 million



Source: UN Dept of Economic and Social Affairs,
 2015 data accessed Jan 2016

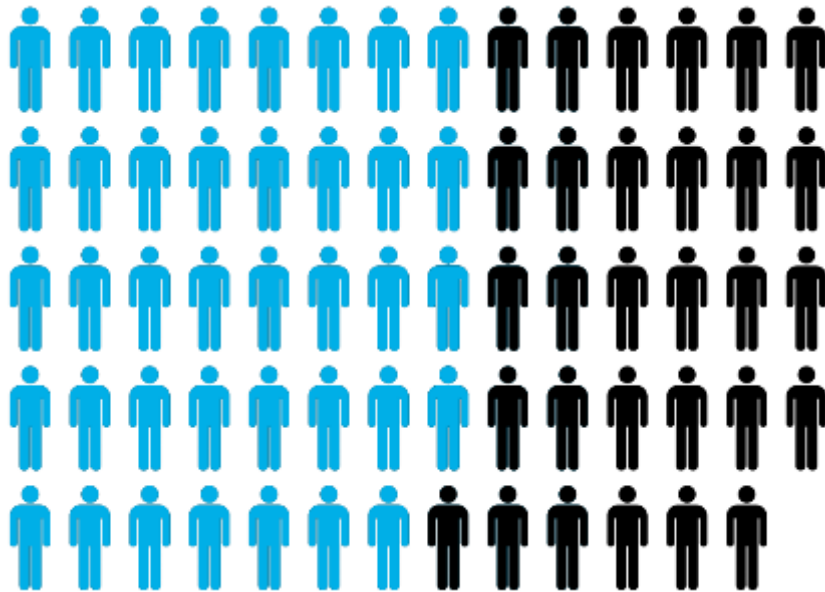



1. Demographic indicators to 2030: China → significant shift to urbanisation

China 2015

Population (everyone): 1.38 billion

Urban population (blue): 779 million

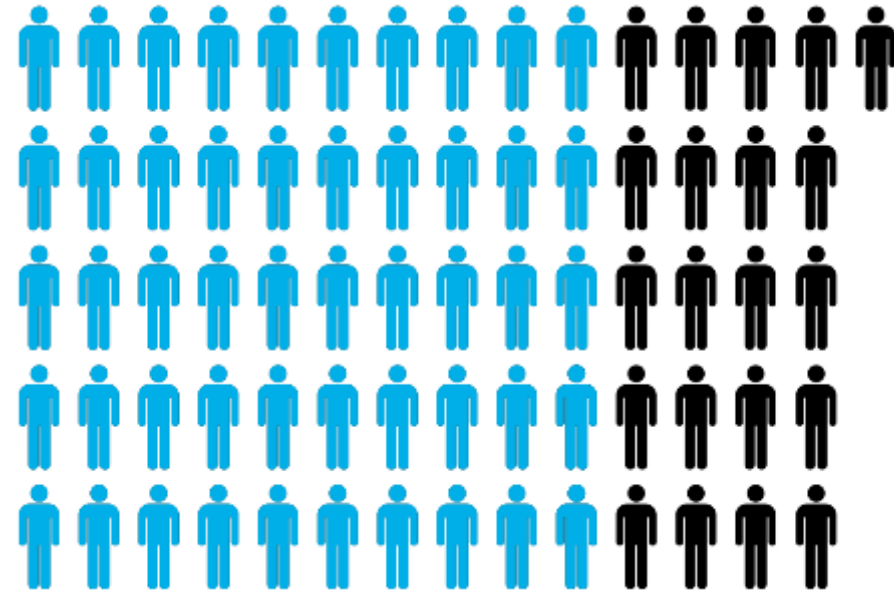


 = 20m people

China 2030

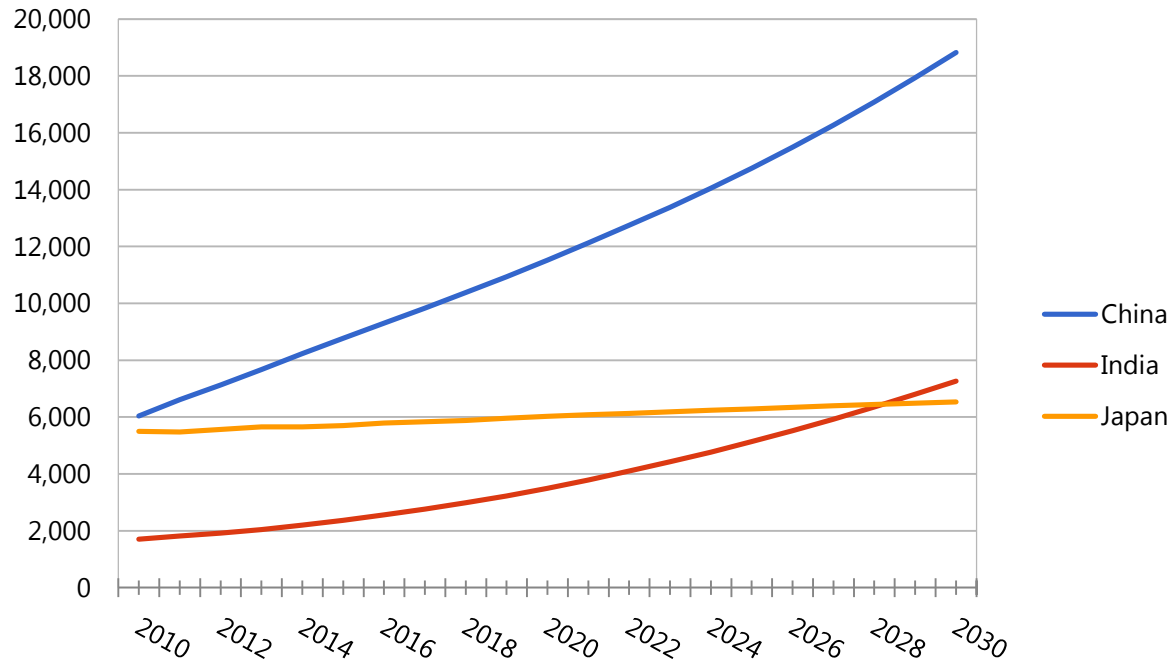
Population (everyone): 1.42 billion

Urban population (blue): 998 million



1. GDP indicators to 2030: Rising wealth of China and India

Real GDP History and Projections (US\$B):
China, India Japan



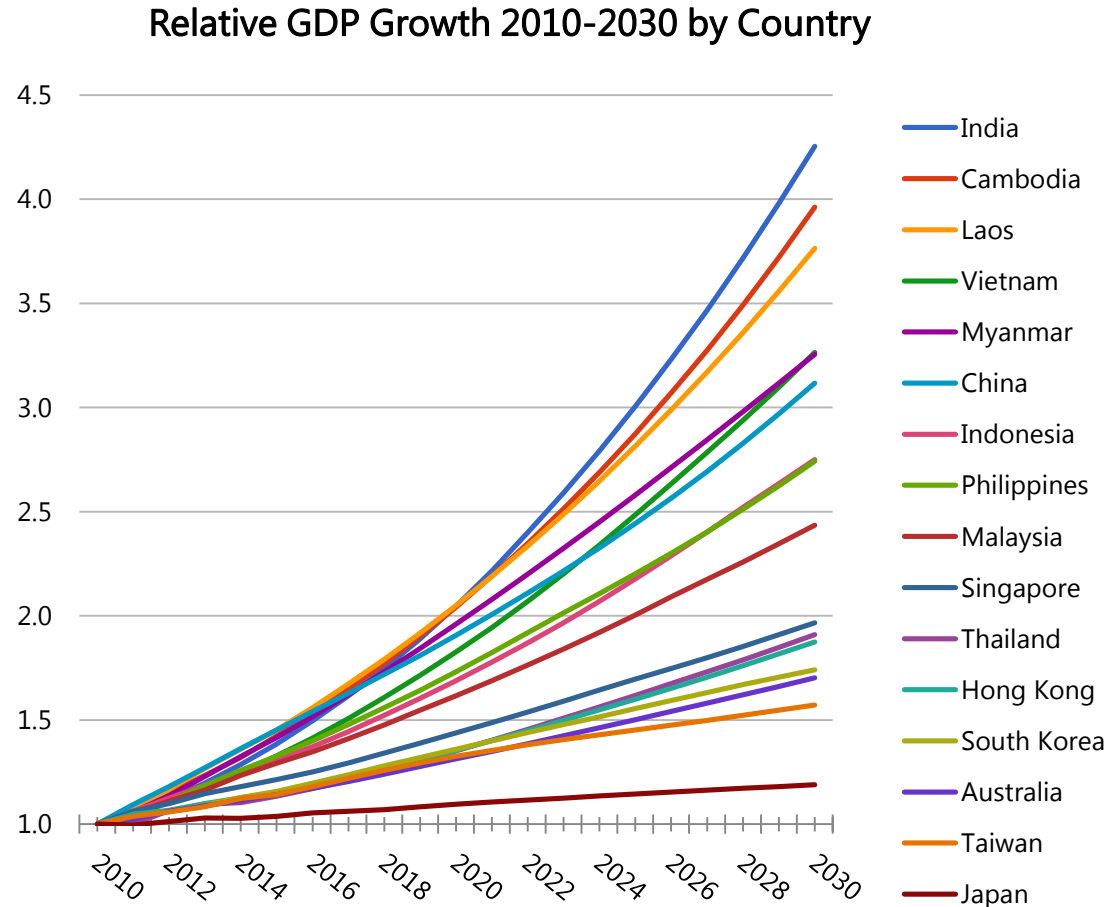
Key messages

- China grows to largest global economy
- India overtakes Japan

Source: USDA, Dec 2015



1. GDP indicators to 2030: Relative Rise of Asian Economies



Key messages

- Rapid growth 2010-2030
- Individual growth rates:
 - India over 3x
 - Vietnam & China over 2x
 - Indonesia & Philippines over 1.5x

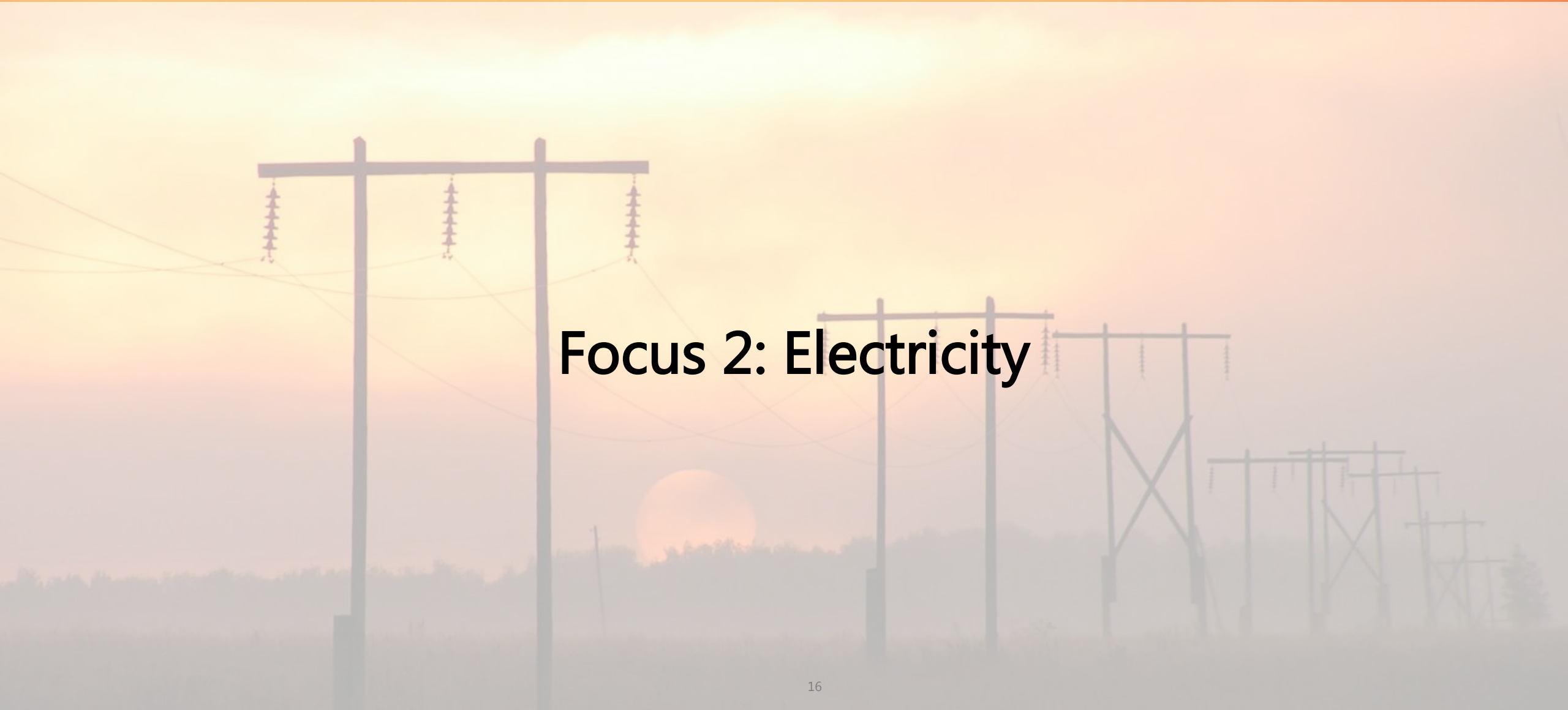
Source: UN Dept of Economic and Social Affairs, 2015



1. Summary:

Demographics, GDP wealth and policies

- Asian middle-class will continue significant growth
 - Urbanisation, transportation, modernised built environment
- East Asian population ageing rapidly (Japan, Korea, China)
 - Low birth rates, longer life expectancy
- Wealth drives rising quality of life expectations
 - Changing policy environment for food safety and pollution
- China strongly signals sustainable development intentions
- India setting goals to increase sustainable standards of living



Focus 2: Electricity

2. Electricity key indicators to 2030: Preview of electricity drivers, issues, uncertainties

Population, urbanisation, wealth drive power demand

- China, India, Asia evolve toward EU/US modern cities

Centralised versus decentralised power evolution

- Australia 2.5% in 2015 → 30% in 2030
- India 7% in 2030
- China 2% in 2030

China National Grid

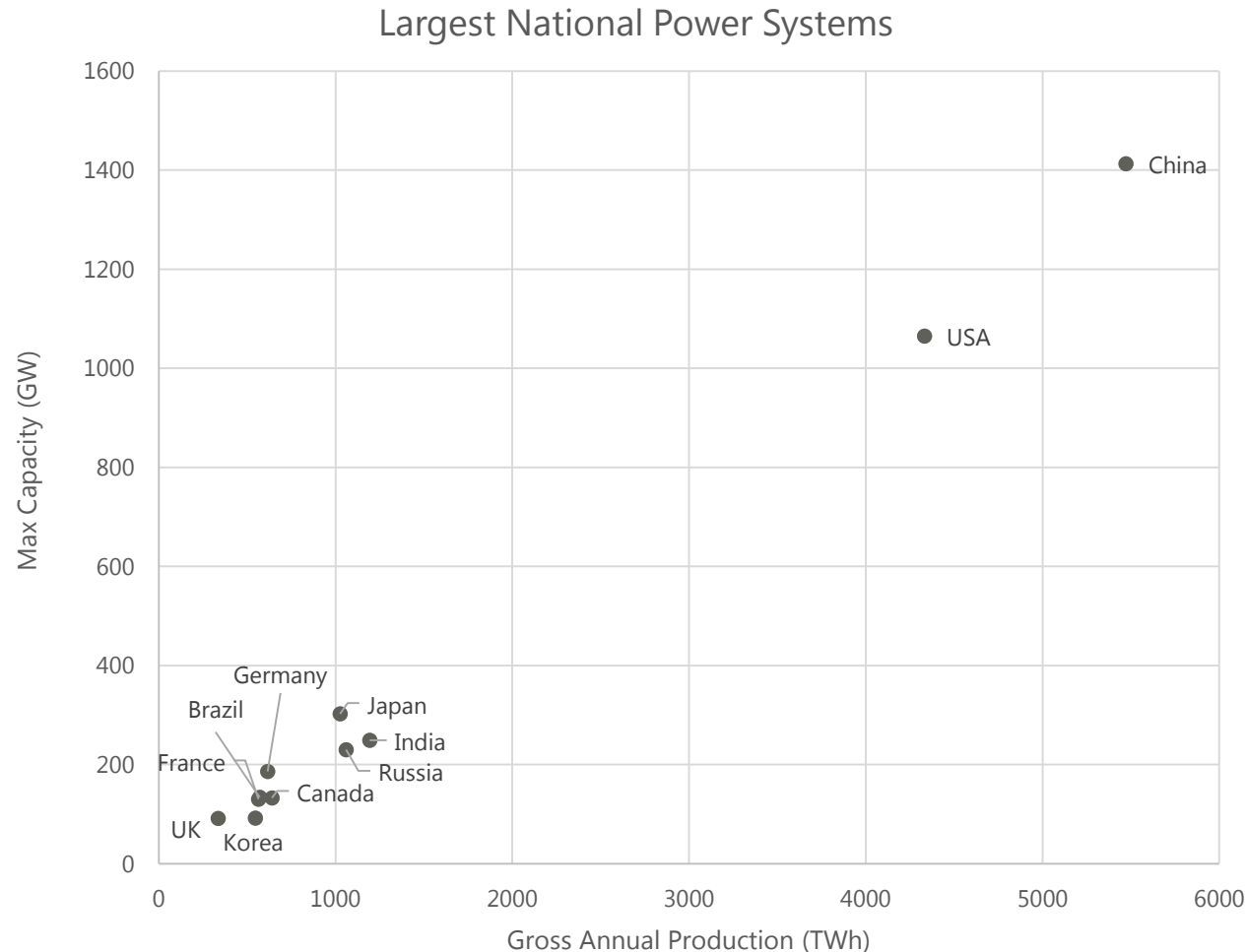
- International connectors less likely 2030
- Long distance high voltage transmission
- Decentralisation constrained, but grows to 2030

Paris Conference (COP21)¹

- Drive towards electrification with lower carbon technologies

¹ 21st meeting of the Conference of Parties (COP) of the UN Framework Convention on Climate Change (UNFCCC)

2. Electricity key indicators to 2030: Asia's power systems among world's largest



Key messages

Capacity

- China: #1, 1413 GW
- Japan: #3, 303 GW
- India: #4, 236 GW

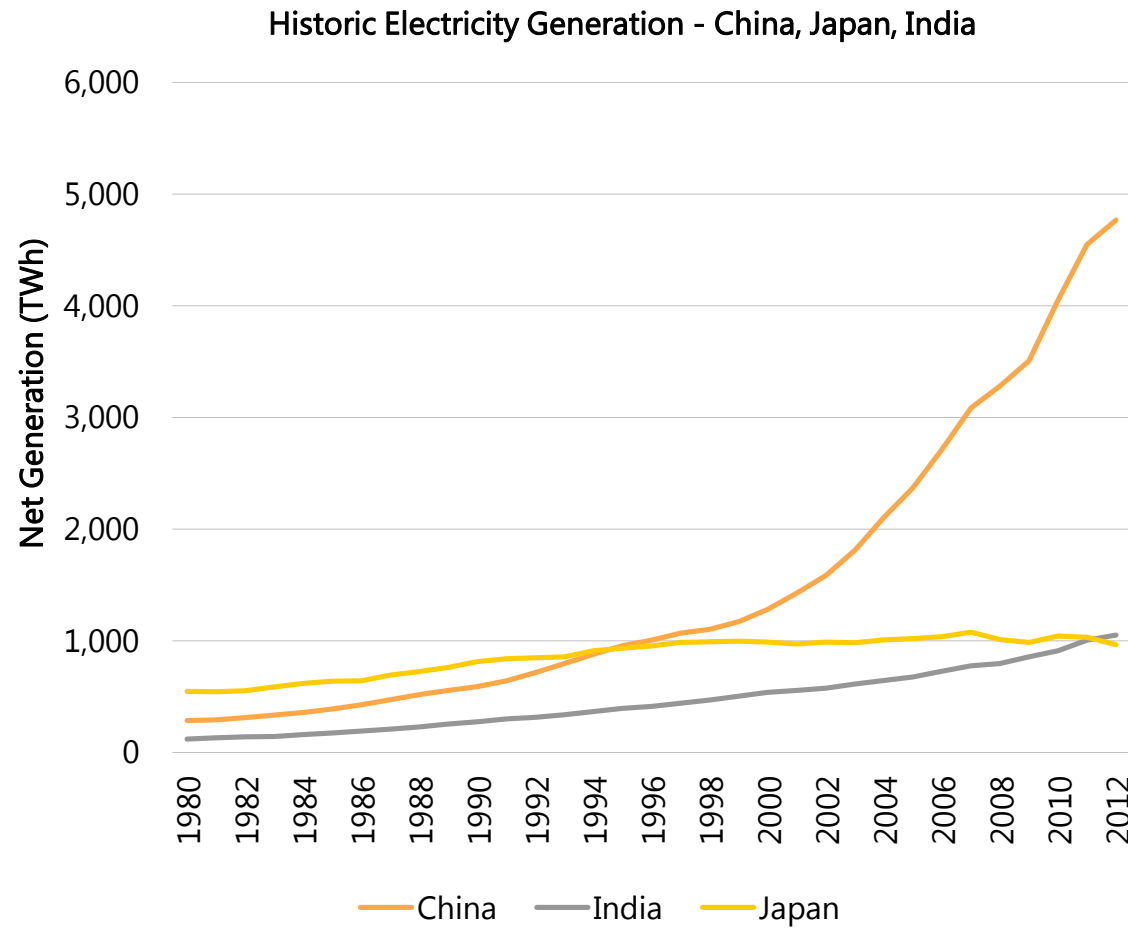
Generation

- China: 1st, 5472 TWh
- India: 3rd, 1194 TWh
- Japan: 5th, 1025 TWh
- Korea, 10th, 545 TWh

Source: Asia Development Bank,
Sep 2014
GW = gigawatt
TWh = terawatt-hour



2. Electricity key indicators to 2030: History of growth in generation...



Key messages

Capacity

- China: #1, 1413 GW
- Japan: #3, 303 GW
- India: #4, 236 GW

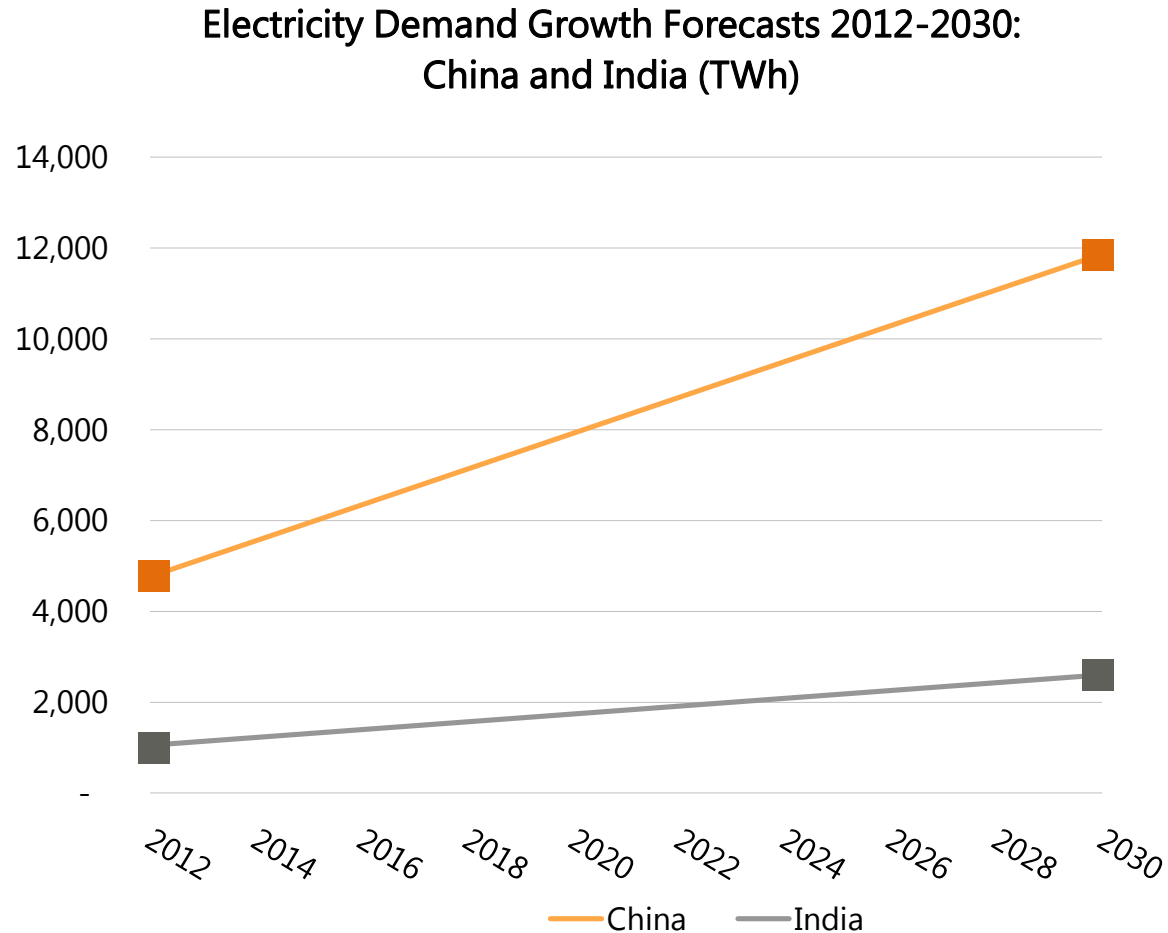
Generation

- China: 1st, 5472 TWh
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- Korea: 10th, 545 TWh

Sources: OECD 2015, OECD/IEA 2015, US EIA 2015



2. Electricity key indicators to 2030: ...continued growth China and India



Key messages

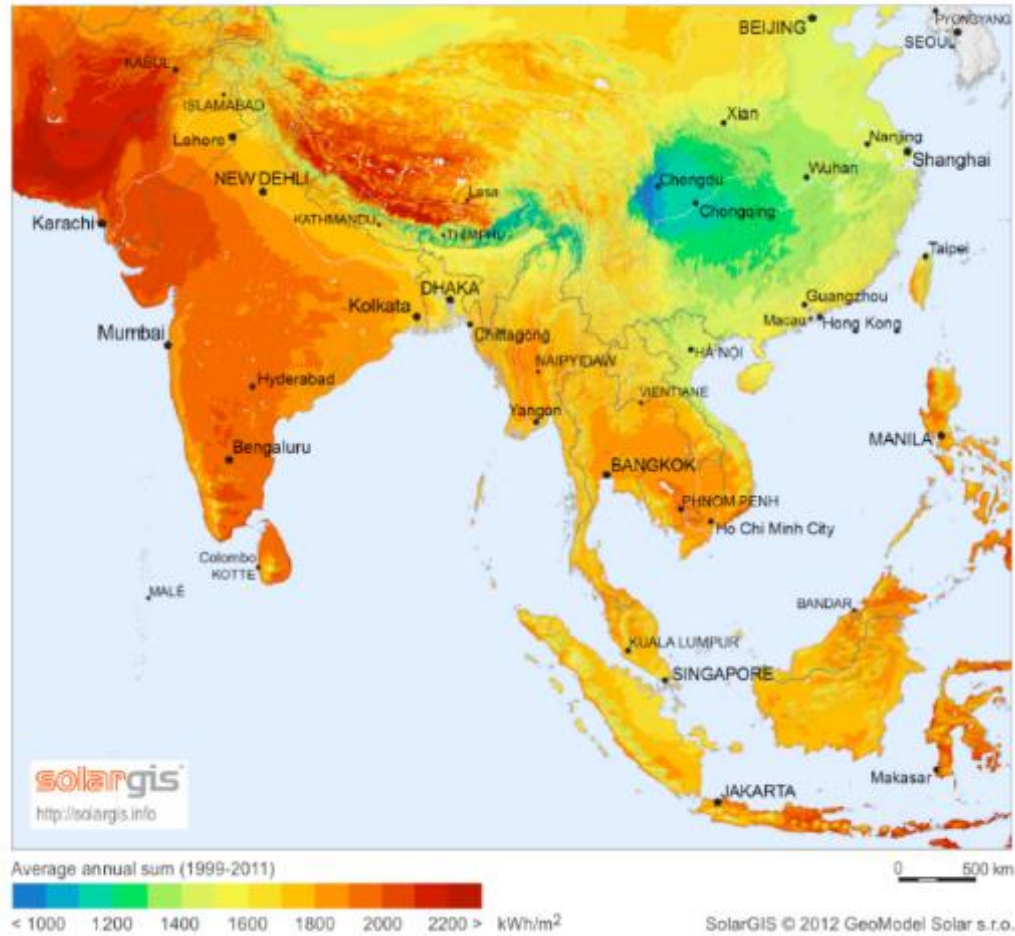
- China and India double to 2030

Sources:
CH – Energy Research Institute, NDRC, 2015.
IN – three estimates: NITI, UNFCC INDC, McKinsey.

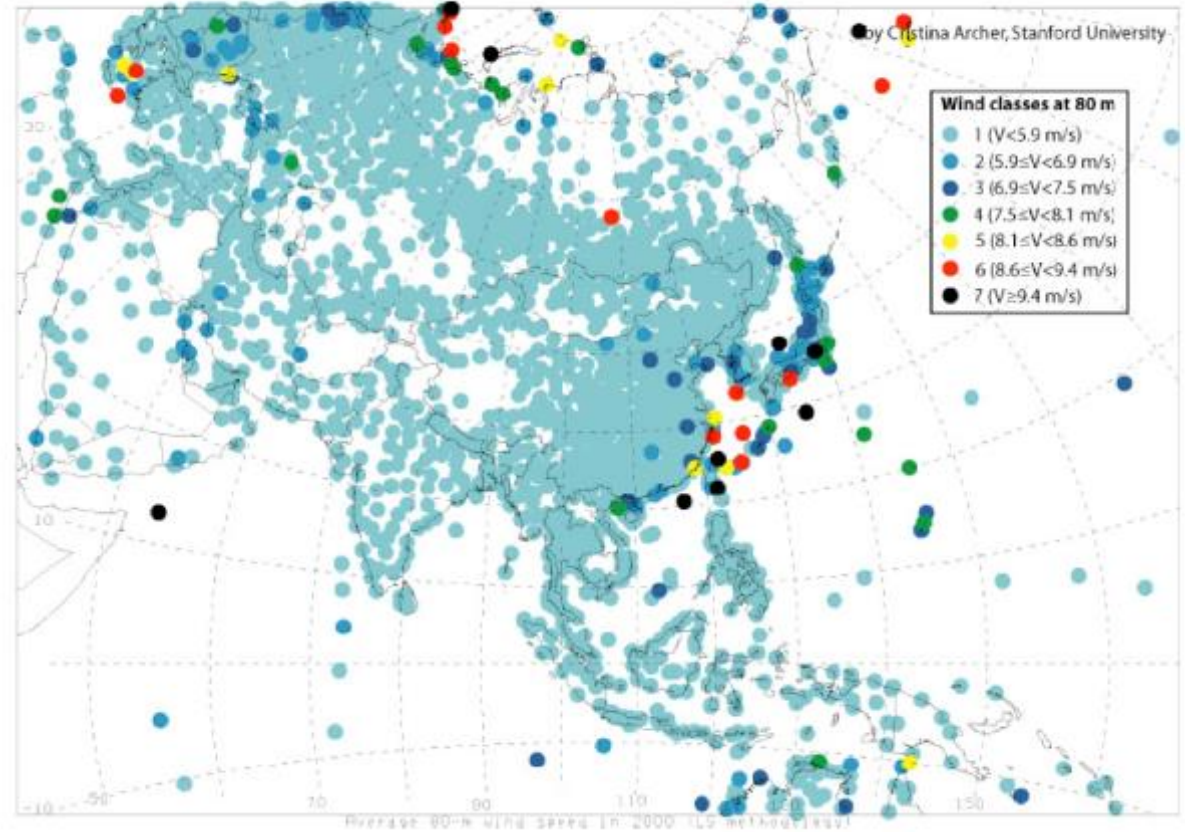


2. Electricity: Solar and wind resources

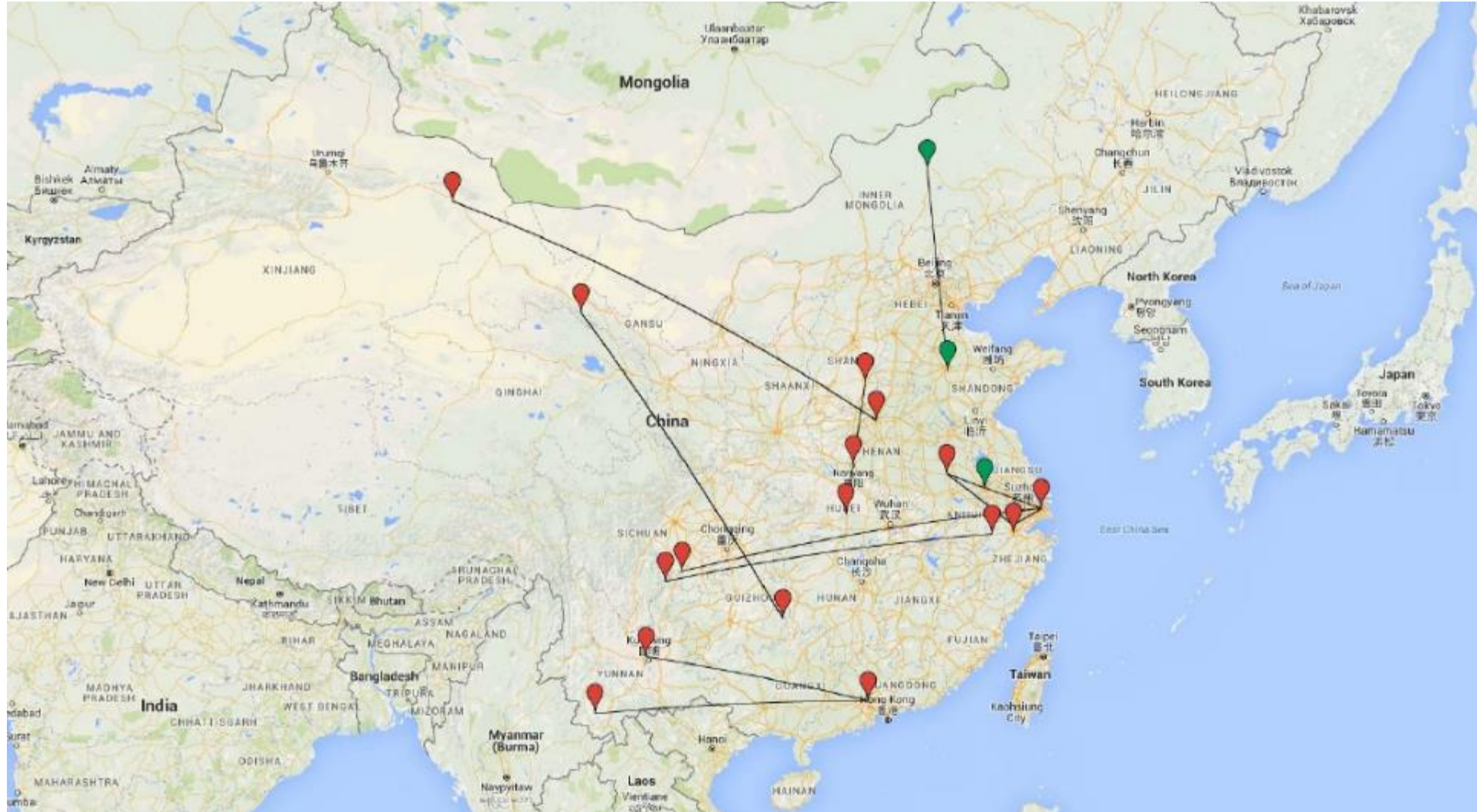
Global Horizontal Irradiation South And Southeast Asia



Asia Wind Map



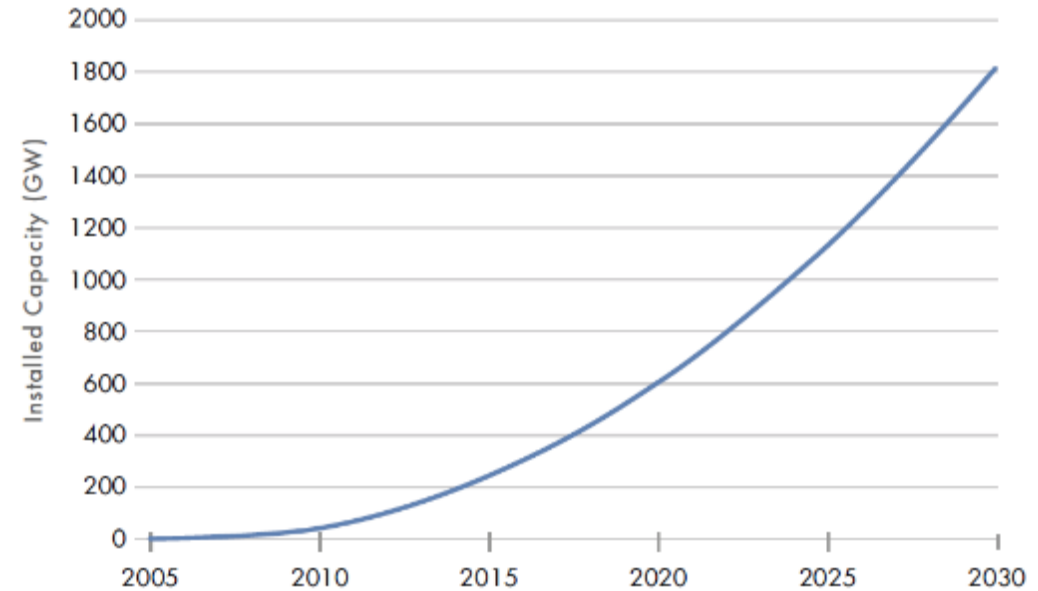
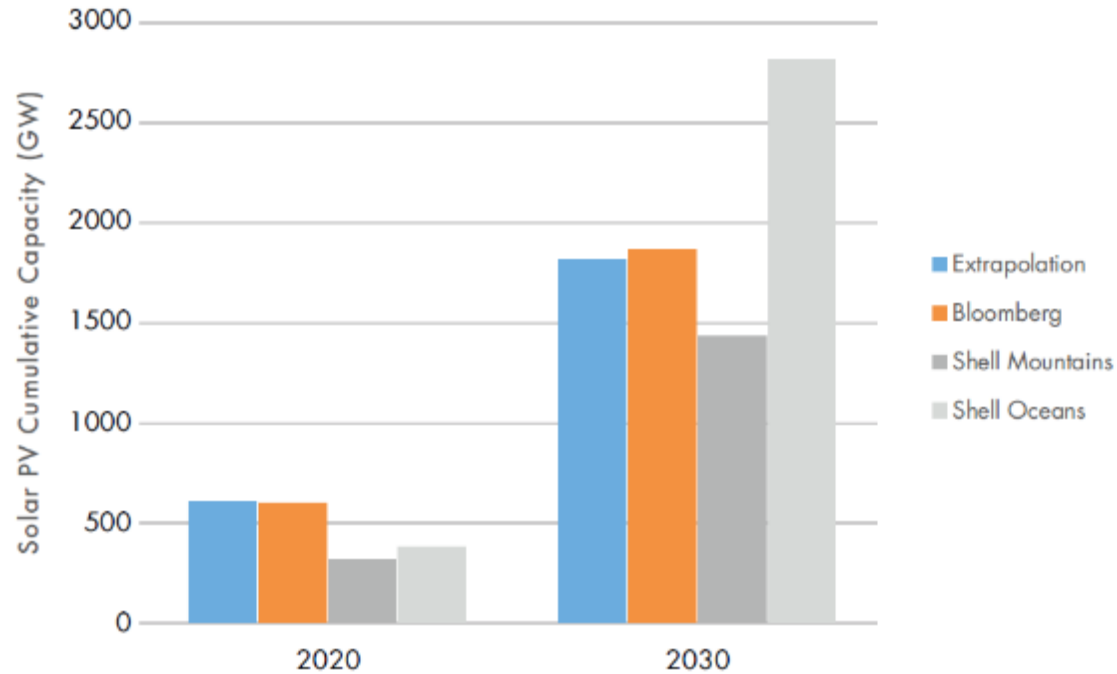
2. China High Voltage Transmission



Source: Warren Centre Google map from Liu Zhenya text



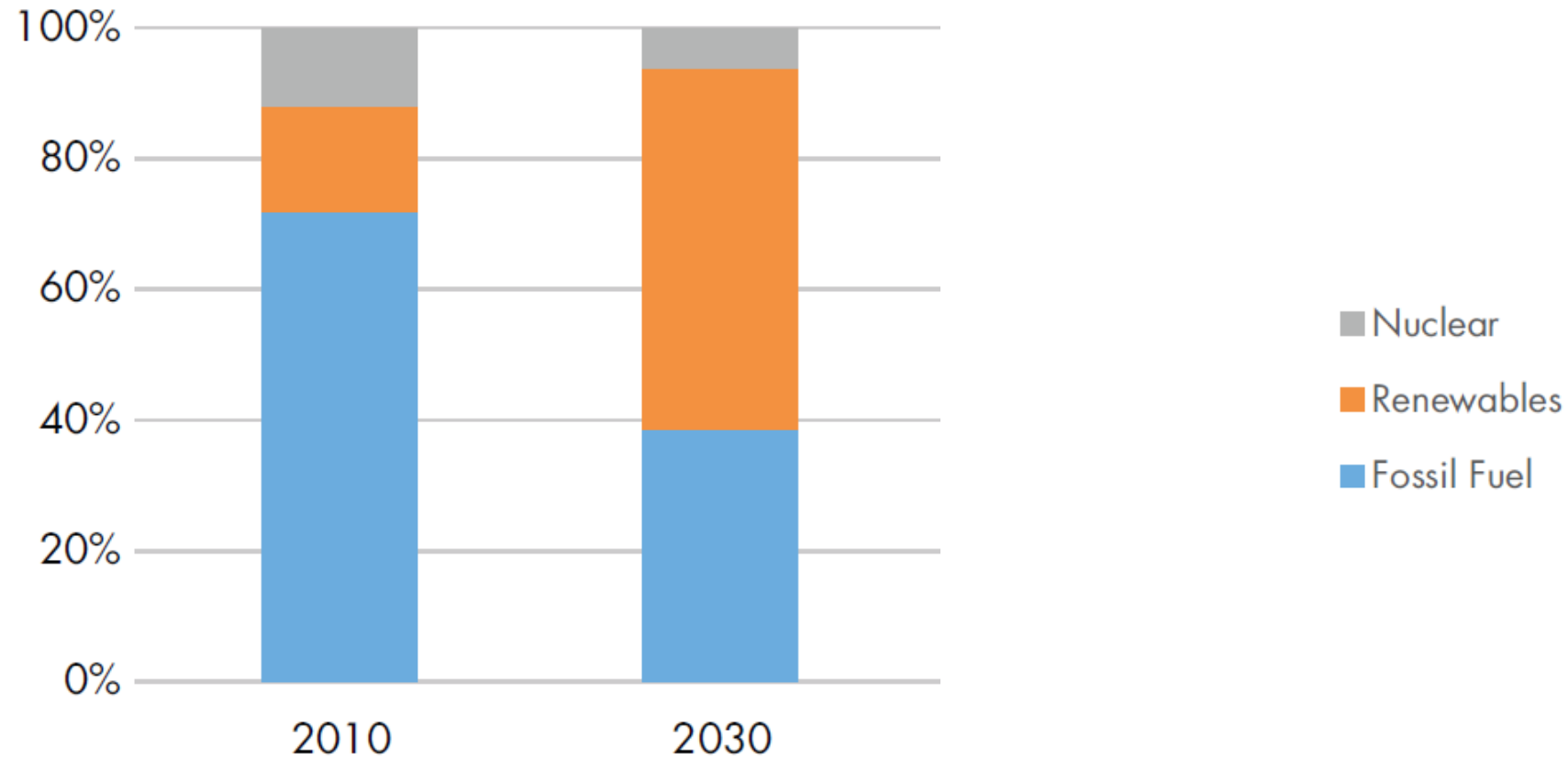
2. Electricity: global solar estimates



Source: as cited. Extrapolation from One Climate Policy.



2. Electricity: Copper within sector



Source: Elshkaki & Graedel, 2013



2. Electricity key indicators to 2030: Summary

- Asia predicted 50% of world electricity by 2030 (2/3 China)
- China coal has peaked. Increased renewables to 2050. Electrification.
- Wind, solar and electric vehicles export growth engines for China
- China power connections to Asia possible, but decentralised more likely to 2030
- Battery technology will become more viable
- Decentralisation trend and urban transmission positive for copper due to shorter transmission distances
- Copper demand from wind and solar generation in China and India:
 - 6.5MT solar PV, 3.6MT wind



Focus 3: Transportation

3. Transport key indicators to 2030: Transport overview

- Increasing population, rising middle class, urbanisation → demand
 - China passenger transport volume tripled in last decade
 - Asia US\$11 trillion basic infrastructure investments to 2030
 - India transport demand grows 2.5 times by 2030
- Urban pollution → electrification policies
 - China vehicle numbers forecast to quadruple again by 2030
- Urban congestion → efficient mass transit investments
- China leads region in manufacturing, influences region.
- Future of mobility likely to be evolved light vehicle solutions and more extensive public transport solutions. Very dynamic space.

3. Transport key indicators to 2030

Public Transport

80-85% Regional growth is China. Much already built.

High Speed Rail

- 2030: China 40,000km; 4,150 trains = 0.55MT tracks, vehicles
- 80% in China. Possible growth if international links built.

Urban Rail

- 2030: China 11,000km; 77,000 cars = 1.0MT tracks, vehicles

Electric Buses

- 2030 region: 1.4 million regional electric buses = 1.5MT

3. Transport key indicators to 2030: Light Electric Vehicles (EVs)

- China's BYD¹ Co Ltd: sales of over 61,000 EVs in 2015
- Capital cost parity of EV² vs petrol by 2025
- 50% penetration of EV forecast by 2030
- Cumulative production of EVs and plug-in hybrids between 2016-2030 to be 75 million vehicles
 - 55% China, 19% India
- Copper: 6,400kT for Light EVs alone; additional copper in EV distribution network and charging equipment

¹ BYD "Build Your Dream"
² EV = Electric Vehicle

3. Transport Summary

- High speed inter-city rail = 0.55MT
- Urban rail = 1.0MT
- Electrified buses = 1.5MT
- Electrified light vehicles = 6.4MT
- Copper in EV distribution network and charging equipment

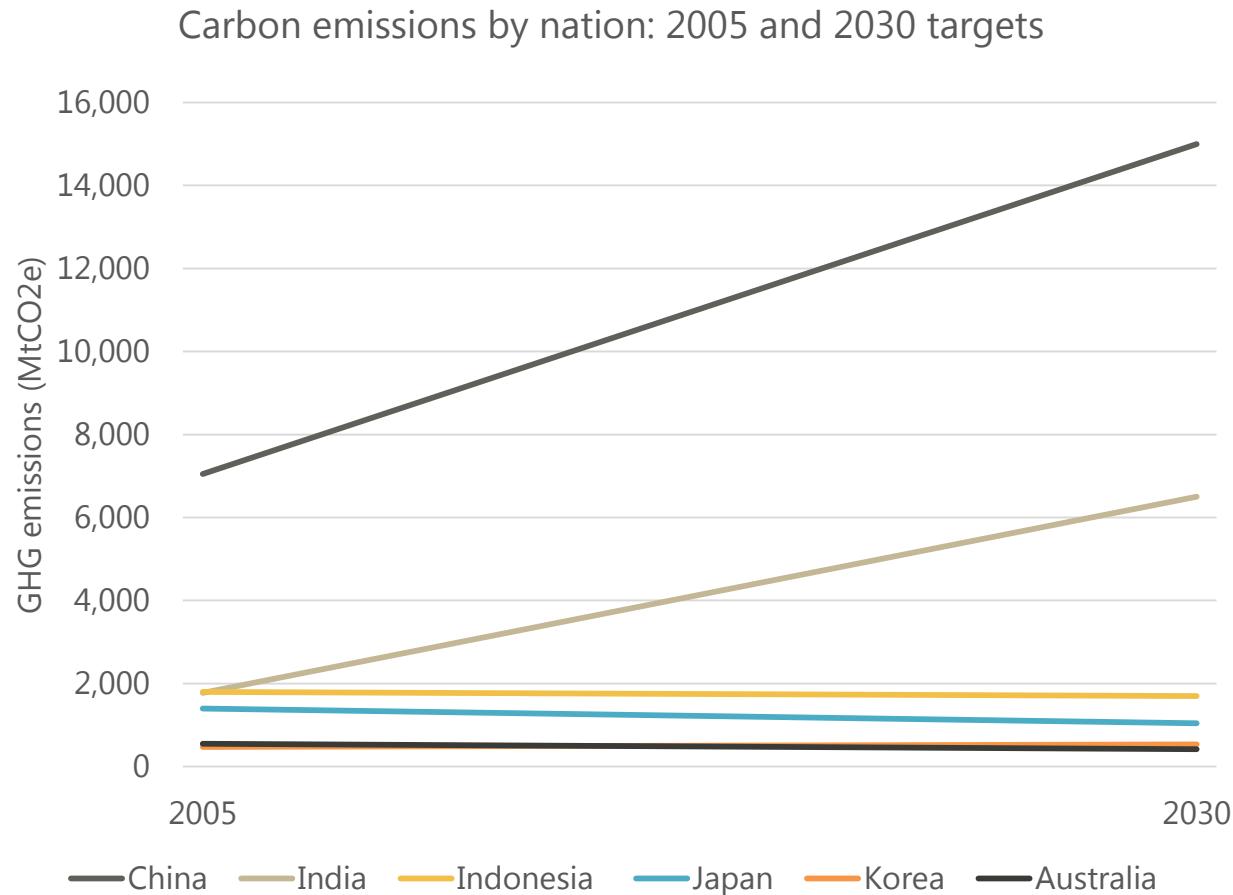


Focus 4: Decarbonisation

4. Decarbonisation key indicators to 2030: Decarbonisation

- Following the Paris Agreement process, China and India to lead the world in decarbonisation
 - Hangzhou G20: Xi and Obama; 55-55 'live' Nov 4
- Emission reduction as economic opportunity
 - Domestic manufacturing industry
 - Export
- Fossil fuels declining with shift to renewables in the electricity sector
- Increased electrification in sectors including building and transport
- Requirements for high energy efficiency favour copper

4. Decarbonisation key indicators to 2030: Paris INDCs¹ impact China & India



Key messages

- **Commitments by China and India**
- **Strong growth in solar PV³ and wind**
- **EU/US financing USD\$100 B/year in 2020 to decarbonise emerging economies**

¹ INDC = Intended Nationally Determined Contribution within the UN Framework Convention on Climate Change (UNFCCC)

² GHG = Green House Gas

³ PV = photovoltaic

Sources: DDPP (Deep Decarbonisation Pathways Project), 2016; UN Dept Economic and Social Affairs, 2015; and Warren Centre analysis.



4. Decarbonisation Summary

Main levers to achieve decarbonisation generally favour copper:

- Asia will continue shift from fossil fuels to renewables in the electricity sector
- Increased electrification in building and transport
- Enhanced energy efficiency
- Where carbon pricing exists, metallic conductor demand shifts towards copper

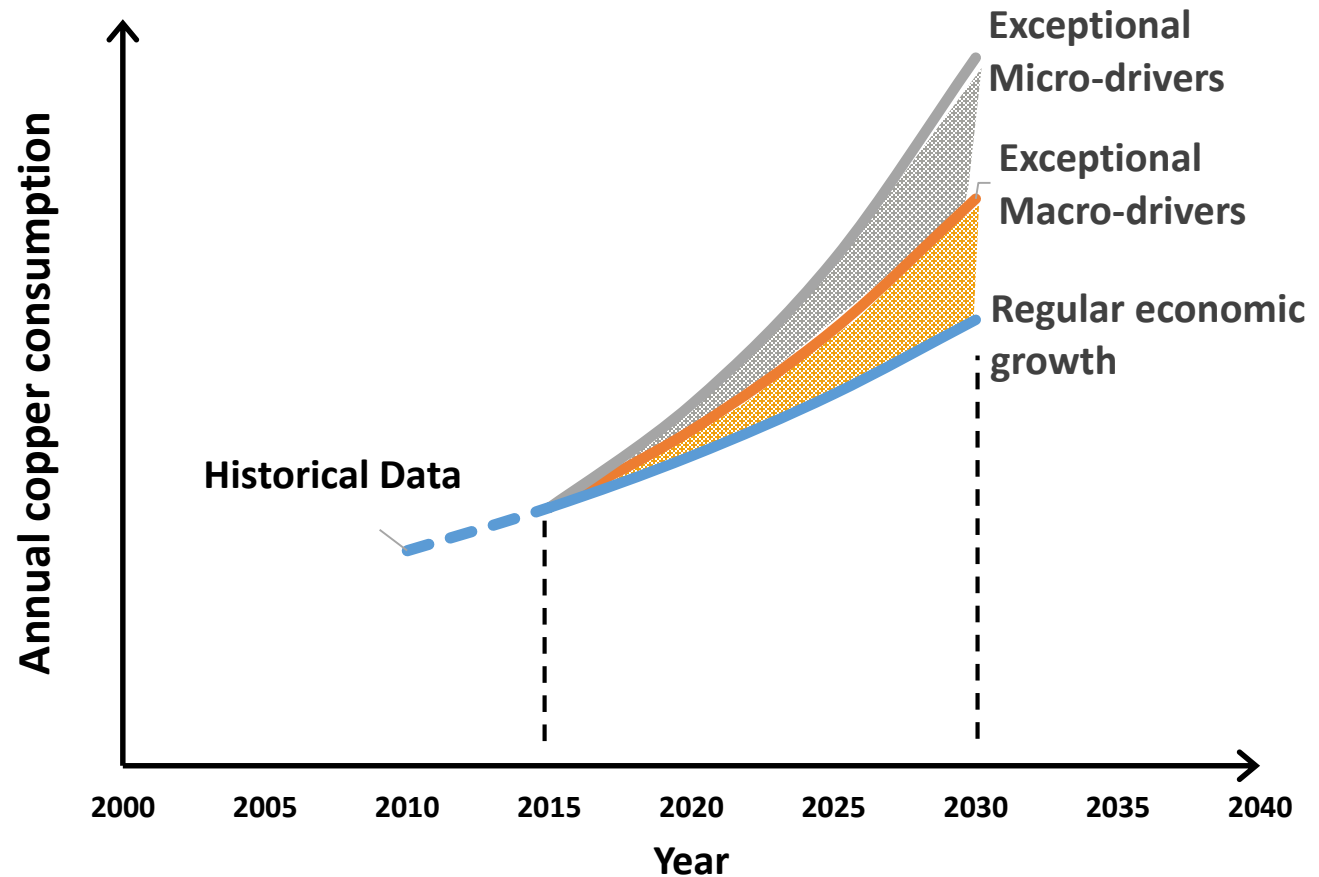
Key Summary:

- Decarbonisation policies will drive copper demand

Interpreting the report

Not estimate of Asia copper market size

- Macro-driver
 - 1. Demographics
- Technologies: mixed macro- and micro-drivers
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- Pure micro-driver
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- Figures are cumulative 2015 to 2030 effect



Total Additional Copper Use 2015-2030

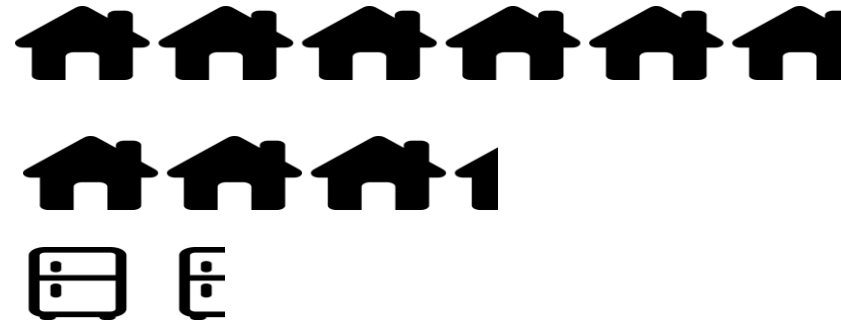
Macro-drivers

1. Demographics
urbansn, wealth

Buildings China: Popn 1.4bn, 65% urban
5.8MT

Buildings India: Popn 1.5bn, 40% urban
3.2MT

Appliances: China and India 1.4MT



Micro-drivers (technologies)

2. Electricity

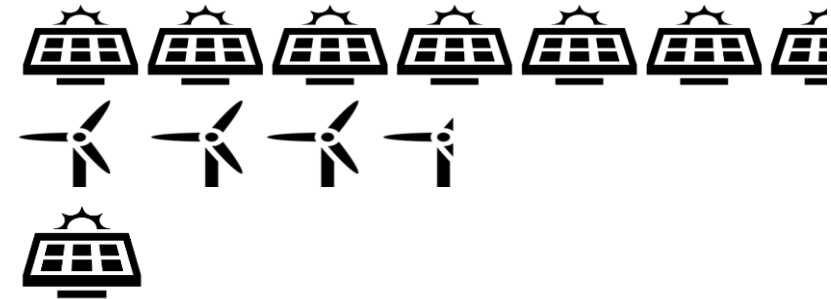
4. Decarbonisation

Clean power, China & India:

Solar PV 6.5MT

Wind 3.6MT

Distributed solar PV 1.0MT



3. Transport

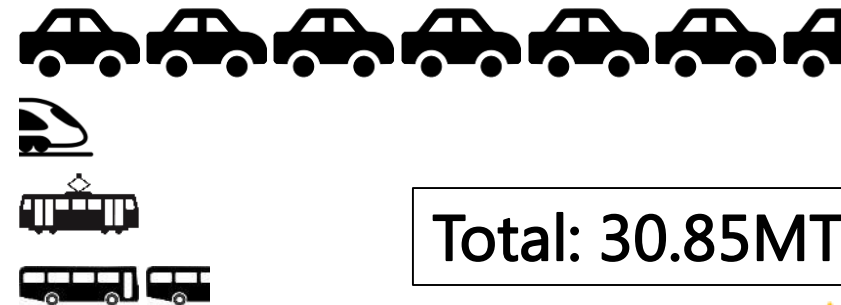
Clean transport:

Light EVs 6.4MT

High speed rail 0.55MT

Urban rail 1.0MT

Electric buses 1.5MT

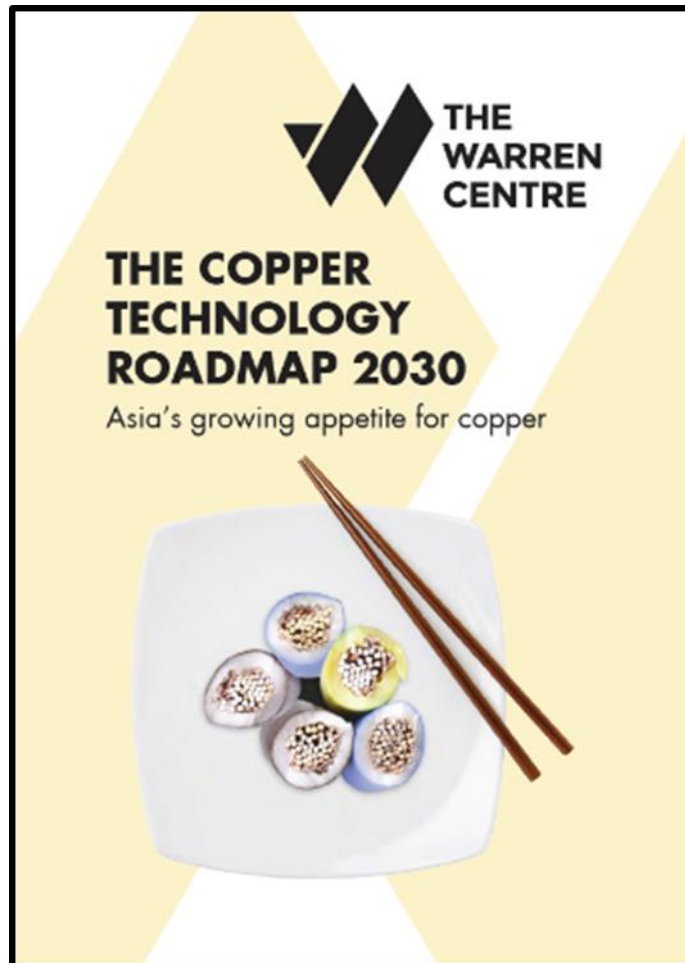


Total: 30.85MT





Copies of report available



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Visit thewarrencentre.org.au or contact ashley.brinson@sydney.edu.au for more information.

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