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1. The role of infrastructure

- Infrastructure is a precondition for economic development and essential for sustainable and inclusive growth.

Infrastructure facilitates participation in the workforce, the production of goods and services, and distribution of products to markets, and promotes technological progress.

Earlier studies using macro-data obtained estimates of elasticities of total output to infrastructure capital of between 0.20 and 0.40 (ADB 2017), implying a 1% increase in infrastructure stock was associated with a 0.20%–0.40% increase in output.

Access to electricity, roads and railways, safe drinking water, and quality communications are all essential parts of people’s welfare. Infrastructure helps children to go to school, women to work outside their homes, and people to stay healthy, and promotes more social interaction.

Many recent micro-data studies, which tried to control the endogeneity problem, confirmed strong contribution of infrastructure to development.
1. The role of infrastructure (cont.)

- Infrastructure is closely associated with development.

Note: Infrastructure index is computed based on first principal component of infrastructure stocks in roads, airport, electricity, telephone, mobile, broadband, water and sanitation. Higher values represent greater infrastructure availability.

2. Overview of Asia’s infrastructure development

- Asian countries made significant efforts to improve infrastructure in the past 50 years, contributed by both public and private sectors. But there were large variations across countries.

**GDP** = gross domestic product, **PRC** = People’s Republic of China

*Central government budget only.

2. Overview of Asia’s infrastructure development (cont.)

- Despite much progress, there remain large infrastructure deficits and differences among countries in Asia.

- In 2017, about 350 million people in the region were without electricity.
- 300 million lacked improved sources of drinking water.
- 1.5 billion lacked improved sanitation facilities.
- 1 billion lived more than 2 kilometers from an all-season road.
- Asia’s contributions to emissions and climate change also remain a concern.
3. Energy

- Major developments in technological infrastructure for the provision of electricity in Asia began as early as the late 19th century.

1878: First public electric lighting system at Tokyo’s central telegraph station.

1882: First Chinese power plant in Shanghai started providing electricity for business and residential lighting and later for industrial manufacturing.

1905: Bangalore (now Bengaluru), India, became the first Asian city with electric streetlights.
3. Energy (cont.)

- Primary energy sources are consumed for electricity and other purposes such as transport and heat as final energy consumption.

Example of primary energy sources
Coal, oil, natural gas, nuclear, hydropower, wind, solar, geothermal, ocean (tidal, wave, and thermal), and biomass

Electricity Generation Per Capita in Selected Economies, 1971 and 2018 (kWh/capita)

- From 1971 to 2018, electricity generation per capita grew dramatically in Asia and around the world.

Note: Per capita electricity generation estimated with Enerdata’s electricity generation data and World Bank’s population data.
3. Energy—Asia’s primary and final energy consumption

Asia’s final energy consumption increased significantly—by 13.5 times—between 1965 and 2018.

OECD = Organisation for Economic Co-operation and Development
3. Energy—Asia’s primary and final energy consumption (cont.)

- In Asia and the Pacific, coal is the primary energy source, followed by oil and natural gas, although the region’s dependency on fossil fuels decreased somewhat as nuclear and renewable energy grew.

**Primary Energy Consumption in Asia, 1965 and 2018**

1965

- Coal: 54%
- Natural gas: 1%
- Oil: 37%
- Hydropower: 8%
- Renewables: 0%

2018

- Coal: 47%
- Natural gas: 12%
- Oil: 28%
- Nuclear: 2%
- Hydropower: 7%
- Renewables: 4%

OECD = Organisation for Economic Co-operation and Development.
3. Energy—Asia’s primary and final energy consumption (cont.)

• Along with rapidly growing energy consumption, carbon dioxide (CO2) emissions have also grown.

![Annual CO2 Emissions (Mt) 1965 and 2018](image)

**Share of Global CO₂ Emissions**

- 1965: Rest of the world (87%) - Asia (13%)
- 2018: Asia (49%) - Rest of the world (51%)

CO₂ = carbon dioxide, OECD = Organisation for Economic Co-operation and Development

3. Energy—Asia’s primary and final energy consumption (cont.)

- The industry and residential sectors are the two largest final energy consumers in developing Asia, followed by transport.
  
  - Industry has the highest share of final consumption in the People’s Republic of China (PRC). In the Organisation for Economic Co-operation and Development, transport has the top share.

**Final Energy Consumption by Sector, 2017**

- **Developing Asia excluding the PRC**
  - Industry: 32%
  - Transportation: 21%
  - Residential: 28%
  - Commercial and Public: 4%
  - Agriculture: 5%
  - Non-energy use: 10%

- **PRC**
  - Industry: 49%
  - Transportation: 16%
  - Residential: 17%
  - Commercial and Public: 4%
  - Agriculture: 6%
  - Non-energy use: 8%

- **OECD**
  - Industry: 22%
  - Transportation: 34%
  - Residential: 18%
  - Commercial and Public: 13%
  - Agriculture: 3%
  - Non-energy use: 10%

3. Energy—Electricity generation and use

- From 1971 to 2018, electricity generation increased 16.5 times in Asia and the Pacific compared to a fivefold increase globally. Electricity generation mix in Asia remained dominated by coal, followed by hydropower and gas.

**Total Electricity Generation, 1971 and 2018 (TWh)**

- Asia: 1971 - , 2018 -
- OECD: 1971 - , 2018 -
- World: 1971 - , 2018 -

**Electricity Generation by Source, 2018**

- Coal: 59%
- Natural gas: 12%
- Hydropower: 14%
- Nuclear: 4%
- Wind: 4%
- Solar: 3%
- Others: 4%

TWh = terawatt, OECD = Organisation for Economic Co-operation and Development
Note: “Others” include oil; biomass, waste, etc; and geothermal.
3. Energy—Electricity generation and use (cont.)

- Over the past 5 decades, Asia and the Pacific made steady progress in providing residential electricity.

- Electricity development in the region can be categorized into three distinct periods of evolution.

1970s: In developing Asia, electrification rate was less than 15% in rural areas.

2000s: Electrification rate was at 67% (both rural and urban).

2017: Electrification rate was at 91% overall.

❖ Electric power development in the region can be categorized into three distinct periods of evolution.

1950s–1980s: From hydropower to the increasing dominance of coal in electricity generation

1990s–2000s: Promoting energy diversification with large hydropower and natural gas

2010s to present: Mainstreaming renewables and energy efficiency
3. Energy—1950s to the 1980s

- During the 1950s through the 1980s, there were large investments starting with hydropower to an increasing dominance of fossil fuels such as oil and coal.

**Hydropower**
- Hydropower was among the first utility-scale power plants in Asian economies, including in Japan (1891); India (1897); Taipei, China (1905); and Nepal (1911).
- Hydropower maintained a relatively stable share in Asia’s primary energy mix, with the proportion declining slightly only as other fuel sources grew faster.

**Oil**
- The share of oil for electricity generation peaked at 49% in 1973 as two rounds of oil crises in the 1970s created an upward spiral of oil prices. Subsequently, oil use for electricity generation declined as coal became more competitive and readily available.

**Coal**
- The region gravitated from oil toward coal because the region has many coal resources—42% of the world total.

Electricity generation and transmission were generally operated by state-owned enterprises (SOEs).
3. Energy—1990s to 2000s

- From 1990s to 2000s, Asian countries started promoting diversification for electricity generation, including the use of large hydropower and natural gas.

  **Large hydropower**
  - Technological progress made large-scale dams more feasible.
  - Between 1995 and 2005, hydropower generation in the region increased by 50%.

  **Solar and wind**
  - Solar and wind energy began to grow rapidly, though from a very low base.

  **Natural gas**
  - As power systems became bigger in many countries in the region, natural gas-fired power plants were needed to meet both baseload and peaking demand.
  - Natural gas has also been used increasingly in industries and households as cleaner fuels. From 1995 to 2005, natural gas consumption in the region increased by 92%.

  **Coal**
  - By 1995, the region’s share in global primary energy consumption reached about 27%. Coal consumption accounted for 44% of total energy consumption in the region, much higher than the 26% world average.
3. Energy—1990s to 2000s (cont.)

• Across developing Asian countries, electricity generation capacity grew substantially, while transmission and distribution became more efficient. The sector also attracted private sector investment.

❖ Technological advances led to lower transmission and distribution losses.

❖ Many countries (e.g. the PRC) followed Japan’s example of improving energy efficiency through regulation and financial incentives.

❖ Private sector investment in power occurred in many Asian developing countries, with the PRC, the Philippines, and Indonesia included in the top five countries attracting private investment.
3. Energy—2010s to present

- From 2010s to present, there have been efforts in mainstreaming renewables and energy efficiency.

**Coal**
- Coal remains a significant component of the region’s primary energy mix. However, the growth of coal consumption in the region slowed significantly, to 1.9% annually, on average, from 2010 to 2018 after decades of sustained high growth.

**Solar and wind**
- Solar and wind electricity generation continues to see massive cost reductions, accelerating solar and wind power installation in the region. In 2018, the region had 56% of global solar installed capacity, 42% hydropower, and 40% wind.

**Nuclear**
- Japan’s Fukushima accident led to the immediate shutdown of all operating nuclear power plants in the country (though several have now restarted). It led to a drive for greater energy efficiency, and slowed construction of new nuclear plants in the PRC, India, and other Asian economies.
3. Energy—2010s to present (cont.)

- Various drivers led to Asia’s move toward a low-carbon paradigm. Asia has also made further progress in rural electrification and in promoting private investment and competition in the power sector.

Drivers of Asia’s move toward a low-carbon paradigm:

- Adoption of Sustainable Development Goals
- 2015 Paris Agreement
- Nationally determined contributions under the United Nations Framework Convention on Climate Change
- Policy support for renewable energy (e.g. feed in tariffs, Renewable Portfolio Standard)
- Initiatives towards energy efficiency (e.g. India’s “Perform, Achieve, Trade” scheme)
- The Asian Development Bank’s support for renewable energy (solar, wind, hydropower, and geothermal)

Rural electrification access rates, Central Asia and South Asia

The power sector increasingly turned to markets and private investment and ownership, helped by the creation of new regulatory frameworks.

Competition was introduced at each segment of the electricity market, and subsidies were gradually removed to ensure efficiency and sustainability.

- Achieving universal energy access and expanding renewable energy remain the region’s energy priorities. Asia’s goal is to make energy available, affordable, and clean, all at the same time.

In Asia and the Pacific in 2017, 350 million people still lacked access to electricity, more than half of which are from India.

![Share of People Lacking Access to Electricity](chart.png)

- The trilemma can only be resolved by deploying new, advanced technologies such as renewable mini-grids with battery storage, smart grids to integrate more renewable energy, and ocean energy.
- To reach the last miles of rural electrification, off-grid solutions using solar, wind, and small hydropower units may be the answer.
- The energy sector can also benefit from artificial intelligence (AI) and digital technologies, which transform cities into smart cities.

The transport sector has always played a dominant role in supporting economic growth in Asia. It aids development and provides access to employment, education, and social services. Aviation and shipping enhance regional connectivity, with airport and port development supporting international trade. Urban transport supported rapidly urbanizing populations across the region.
4. Transport (cont.)

- Since 1950, there has been a marked shift from rail- to road-based transportation across Asia.

### Rail Kilometer per Million People

- Japan: 200 (1965), 222 (2014)
- Thailand: 100 (1965), 110 (2014)
- Malaysia: 150 (1965), 170 (2014)
- Republic of Korea: 120 (1965), 130 (2014)
- India: 80 (1965), 90 (2014)
- People’s Republic of China: 50 (1965), 60 (2014)
- Indonesia: 40 (1965), 45 (2014)

### Road Kilometer per Million People

- Japan: 11,000 (1965), 11,000 (2014)
- Malaysia: 5,000 (1965), 7,000 (2014)
- India: 3,000 (1965), 4,000 (2014)
- People’s Republic of China: 2,000 (1965), 3,000 (2014)
- Republic of Korea: 1,000 (1965), 1,500 (2014)
- Indonesia: 1,000 (1965), 1,200 (2014)
- Singapore: 2,000 (1965), 2,500 (2014)

Sources:
4. Transport—1950s–1970s: Emergence from World War II

• Asia and the Pacific went through several fundamental changes from 1950 into the 1970s.

  ❖ Independence and the redrawing of national boundaries brought changes, as some rail networks and operating services were split between countries.

  ❖ In much of developing Asia, the 1950s to 1970s saw early road network development, often supported through international assistance.

  ❖ Asia’s car manufacturing began reaching industrial scale in the late 1960s.

  ❖ During the 1950s–1970s, a fledgling trucking industry started taking advantage of the emergence of new highways and their wider coverage.

  ❖ Governments were also focused on expanding roads, which made cars and trucks the dominant mode of transport.

  ❖ During the 1950s and 1960s, many railroad networks suffered from political neglect, leading to a deterioration of service and operations.

  ❖ In the 1970s, railways fell into a period of significant underinvestment, leading to a vicious spiral of decline.
4. Transport—1980s–1990s: The road boom years

- During the 1980s–1990s, roads solidified their place as the dominant mode of transport across Asia.
  - As economies grew rapidly, the demand for travel and shipment of goods increased.
  - Economies such as Malaysia; the Republic of Korea; and Taipei, China began embracing Public-Private Partnerships to expand their road networks.
  - Japan’s high-speed railways started to change the perception of railways in many developed countries. But it also saw a decline in demand and level of services on their traditional railways.
  - The rest of Asia continued to allow rail networks and services to decline during the period.
4. Transport—2000s: Wide-scale congestion appears

• From the 2000s onwards, road congestion becomes a critical issue in many developing Asian countries.
  ❖ Large-scale congestion in major road networks started in the 2000s, as these expanded networks were unable to keep pace with the increase in vehicle ownership and use.
  ❖ Vehicle pollution has also become a serious problem in many areas.
  ❖ During this period, a shift began toward a new age of railways in some developing economies.

![Vehicle Registration, Selected Asian Economies](image_url)

4. Transport—2010s: Pursuing a more balanced approach

- The 2010s saw a much more balanced approach to transportation system investment and operations.
  - During the 2010s, road investments no longer dominated, while investment in railways continued to grow.
  - New railway opportunities also emerged during this period. Many Asian countries, such as India and Bangladesh, started to heavily invest in railways.
  - Strong growth throughout Asia, along with the growing problems of traffic congestion, air pollution, and the impact on climate change, brought the need for more efficient freight and public transport services.

High-Speed Rail Activity in Key Regions, 2000-2016
(billion passenger-kilometer)

PRC = People’s Republic of China.
Since the turn of the 21st century, there has been a significant increase in investments in public transport such as metros and buses.

- Rapidly urbanizing populations began to place immense pressure on cities to address increasing travel demand. Some cities attempted to build their way out of congestion with elevated expressways.
- Asia’s megacities now lead the world in subway networks—such as in Beijing, Shanghai, Seoul, and Tokyo.
- The Asian Development Bank has been supporting urban public transport including subways; bus rapid transit systems, and integrated multimodal transport (in Mongolia, Nepal, and Sri Lanka).
4. Transport—Future trends

- Transport sector in Asia will continue to address issues of safety and sustainability and need for technology innovations.
  - Congestion remains, or is even increasing, in many Asian urban areas.
  - Worsening road safety has also attracted more attention. Asia accounts for 53% of worldwide fatalities from road crashes.
  - Transport infrastructure and operations will continue to require investment in both new and existing assets, with new technologies playing an increasingly important role.
  - Over the next 20–40 years, the sector could see wholesale decarbonization. Electric vehicles (e-vehicles) will most likely replace combustion engines over time, which is already starting to happen and most of the change has been in Asia.
The development of urban water systems in Asia and the Pacific has been an interesting journey ...

From the basic aqueduct systems of the Indus Valley Civilization in South Asia around 3000 BC ....

... to the development of engineered gravity and mechanized bulk water supply systems.

.... and to the emergence of today’s digital technology water management systems.
5. Urban water supply—Pre-1960s

- Before 1960, colonial water supply systems were the main sources of urban water supply in many countries.

  - Before the development of engineered water systems, people got their water supply directly from rivers, lakes, springs, underground sources, and rainwater, among others.

  - In the PRC, the grand canal, built in the 6th century, was used as drinking water.

  - Colonial water systems were built in Asian cities in the late 1800s to early 1900s.

  - Urban water systems in the region before 1960 were infrastructure intensive, featuring engineered reservoirs, piped transmission, and distribution networks.
5. Urban water supply—1960s to 1980

From 1960 to 1980, Asia transitioned to decentralized and local water utility management—to meet growing urban demand.

❖ After independence, many countries transferred urban water supply management to national or provincial governments, or to local water utilities—to meet demand from growing urban population.

❖ Some cities that overcame these challenges (e.g. Singapore) were supported by central governments with better policy, management, and technological solutions.

Urban Population in Asia, 1960 to 1980 million
(100 million people)

In the 1990s, urban water services were increasingly privatized. But more recently, there has been a shift from privatization to corporatization of publicly-owned water utilities.

- Involving the private sector through PPPs to reform urban water services in developing countries gained ground during the 1990s—they would help solve inefficiencies in operating and managing government-run water utility systems.

- More recently, there has been a shift in thinking from privatization to corporatization of publicly-owned water utilities, due to: (i) the idea that water delivery should be a public service; (ii) private companies shying away from the financial risks inherent in investing in water utilities; and (iii) the goal of reforming the public water utilities.

- Dhaka in Bangladesh and Phnom Penh in Cambodia have turned low-performing institutions and inefficient systems into high-performing and profitable water utilities through corporatization.
5. Urban water supply—Future trends

- Water supply continues to be a challenge in many cities. Future trends require integrated solutions for a water-secure future in the region.

  - Remaining challenges: High water loss in distribution networks, low revenues and financial sustainability, overstretched capacity
  - Possible solutions: Using advanced technology such as geographic information systems; smart networks; and metering technologies.
  - Governments, the private sector, and development partners all have a role in financing water infrastructure. And the sector must be integrated with bulk water supply, wastewater management, flood risk management, solid waste management, source protection, and integrated water resources and drought management.
  - Governments are also expected to play a critical role in creating an enabling ecosystem of appropriate policies, regulations, and taxes—including environmental charges.
6. Telecommunications and information and communications technologies—Telephone infrastructure

- Asia adopted technology both as an input and output of development. From the 1960s onward, wider telecommunications use and later, information and communications technology (ICT), developed rapidly.

  - Japan had its first telephone service in 1890 and, by the mid-1960s, had 15 telephones per 100 inhabitants. Meanwhile, India peaked at only 4 telephones per 100 inhabitants in 2005.
  - Asian economies rapidly developed fixed telephone infrastructure in the 1960s and continued to expand until the mid-2000s, when mobile phones became widely available.

The availability of low-cost mobile phones has spread their usage phenomenally, today reaching a majority of the population worldwide.

Widespread smartphone use has opened new opportunities for development purposes, including in health, education, employment, social services, and finance.

6. Telecommunications and information and communication technologies—Computing and internet

- In Asia and around the world, there has been a rapid expansion of internet usage and the digital economy.

- The digital economy covers e-communication, e-commerce, ride-sharing, digital payments, and online education. It also extends to digital employment like the growing call center industry in India and the Philippines.

- Examples of digital economy leaders: WeChat, Alibaba, Grab and Gojek.

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**1973:** Japan and Australia start to become connected to the ARPANET (Advanced Research Projects Agency Network).

**1980s:** Japanese firms became leaders in semiconductor industry.

**1990s:** The Republic of Korea followed Japan in being leaders in the semiconductor industry.

**1990s:** Desktop computers became popular.

**2000s:** Google and Amazon became dominant platforms in Asia.

**Mid-2000s:** Cloud computing emerged as a new form of infrastructure.

**2018:** More than 50% of the population had internet access.

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**Internet Users**

(% of population)

• Going forward, there are several digital infrastructure trends that will continue to transform Asia’s economy. These include the Internet of Things (IoT), artificial intelligence (AI), and cybersecurity and privacy protection.

IoT Infrastructure can support development. For example, it can improve agriculture by remotely monitoring soil conditions and air quality.

AI is promising for new services such as optimizing crop inputs for farmers, fine-tuning medical diagnosis, translating documents using smartphones, and tailoring education for students through adaptive learning.

As more and more human activities are digitized, cybersecurity and privacy protection will grow in importance.
7. Looking ahead

• Developing Asian countries need to address gaps in infrastructure.

  ❖ First, more investment is needed in infrastructure. These investments should have strong economic rationale, efficient life-cycle costs, and positive social and environmental benefits, and incorporate advanced technologies.

  ❖ Second, continuing capacity development and institutional reform are needed to boost efficiency and deliver high-quality services. These include for example, tariffs for utilities, and subsidies for poor households.

  ❖ Third, the private sector can mobilize knowledge, operational efficiency, and additional financing to help develop infrastructure projects. Government has an important role to play in creating the right policy environment and setting priorities to encourage private sector participation.

  ❖ Finally, regional cooperation to improve connectivity across Asia and the Pacific is essential to unleash the region’s potential, and to promote growth and stability.
8. Questions and further readings

- **Questions**

  01. Why does infrastructure matter for development? What are the current gaps in infrastructure in Asia and the Pacific?

  02. Explain the three phases of evolution of electricity development in the region. What were the developments for each energy primary source?

  03. What are the remaining challenges in urban water supply provision in Asia? What are the most viable solutions for these?

  04. How can Asian countries solve traffic congestion and inadequate road safety in their cities?

  05. Give examples of digital trends in the region and how they are foreseen to impact Asian economies.

  06. What have been the roles of the private sector and government in the development of water, energy, transport, and ICT infrastructures?
8. Questions and further readings (cont.)

• **Further readings**


Thank you!

The soft copy of the book can be downloaded at

https://www.adb.org/publications/asias-journey-to-prosperity