Lecture 7

Managing Resources (I): Renewable Energy

KEY QUESTION:

How do we manage the use of renewable energy sources?

With the completion of this lecture, attached readings and tutorial, you should be able to discuss:
- Potential of solar power and hydropower to reduce dependence on fossil fuels as energy sources
- Limitations of solar power and hydropower in providing energy security
- Trade-offs associated with solar power and hydropower: economic, environmental and social considerations

<u>Lecture Outline</u>

<u>Reading 1</u>: Why hasn't solar energy in Singapore taken off in a big way after so long?
<u>Reading 2</u>: The cost of Laos' quest to be Southeast Asia's 'battery', and the World Heritage town at risk

Workers installing solar panels on the roof of a house during a hot day in Singapore.

7.1 Energy security and the role of renewable energy

- **Energy security** is defined as **the reliable supply of energy at reasonable prices**. Energy security can be studied in these aspects:
  - long-term energy security mainly deals with timely investments to supply energy in line with economic developments and environmental needs.
  - short-term energy security focuses on the ability of the energy system to react promptly to sudden changes in the supply-demand balance.
- Globally, fossil fuels are burned to supply more than 80% of the world's energy (see **Fig. 1**). There are many reasons to explain their continued adoption by countries to ensure energy security (see **Table 1**). These include their already ready availability which is further aided by how technology helps to find more of these sources (e.g. hydraulic fracturing for shale gas) as well as relatively stable prices (such as for coal).
- However, emissions of carbon dioxide from fossil fuel combustion and industrial processes contributed about 78% of total greenhouse gas emission increase between 1970 and 2010. Our heavy reliance on burning fossil fuels such as coal and oil for electricity generation has encouraged the release of carbon dioxide into the atmosphere much faster than the Earth can reabsorb them into carbon sinks (such as forests). (More on this in **Cluster 3**)
- Coupled with our ever-increasing demand for electricity, it is easy to predict that carbon concentration in the atmosphere will only intensify unless environmentally-friendlier sources of energy are found.
- Much attention has thus been cast on sources of energy that will release less carbon than the burning of fossil fuels would. Renewable energy sources could significantly reduce greenhouse gas (GHG) emissions. Many are already proven and effective sources of energy, but at only 11%, remain dwarfed by consumption of coal, oil, and gas (see again **Fig. 1**).
- In this lecture, we examine the potentials of renewable energy sources as a solution to energy security, using solar power and hydropower as our case-studies. We also consider the reasons for their relatively slow acceptance by countries despite the benefits that they can bring.

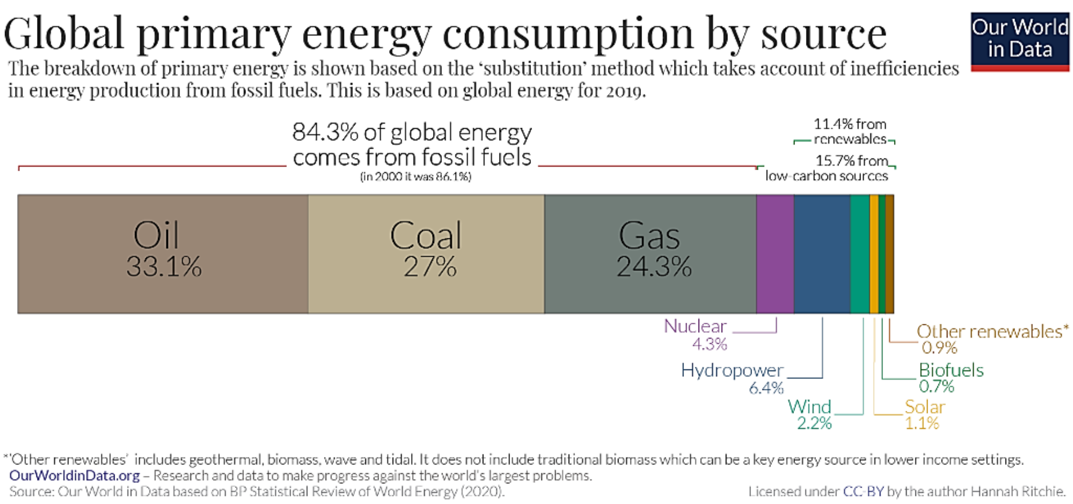

Fig. 1

Table 1. Advantages and Disadvantages of Fossil Fuels

Fossil Fuels	Advantages	Disadvantages
Oil	• Indispensable in road transport • Petrochemical industries generate various products and by products which are valuable raw materials for other industries • Leading tradable commodity • Flexible use – can be distilled into different fuel products • Easy to transport and store fuel • Cleaner and easier to burn than coal • Most economical source of energy	• Non-renewable – takes millions of years to form • Burning oil generates CO_2, a GHG • Sulphur from oil combines with moisture in atmosphere to produce acid rain • Not as clean or efficient in use as gas • Serious oil spills from super tankers and pipelines • High price volatility • Geopolitical tensions in areas with the largest reserves • Market is dominated by leading oil-producing countries and large TNCs • Concerns that 'peak oil' (i.e. when global oil extraction goes into decline, creating shortages and price hikes) is not far away
Natural Gas	• Cleanest of fossil fuels • Flexible and efficient fuel for power and heat generation • Increasing proven reserves from unconventional sources (reassessment of speculative reserves and shale gas)	• Reserves increasingly off shore or in more remote areas • Large investment requirement for gas transport and distribution • Increasingly long supply routes with high infrastructure costs
Coal	• Wider geographical distribution and more plentiful reserves • New technologies to improve environmental performance • Stable prices	• High emissions of carbon, particulates and other pollutants • Environmental mitigation such as carbon capture (use) and storage (CCS/CCUS) have a negative impact on energy efficiency

7.2 Solar Power

- Solar energy is the technology used to harness the sun's energy and make it useable. In 2019, the technology produced about 1% of global energy demand (see **Fig. 1**).
- Photovoltaic (PV) cells, or solar panels, are required to help with the conversion process. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity. (See **Fig. 2**)
- Current solar energy reaching the Earth's surface (198 W/m^2) far exceeds all current energy requirements. Solar energy can be used for heating of buildings, be converted into electricity with photovoltaic cells on solar panels. However, use of solar energy requires site characteristics, e.g. site must have "solar access" – not having buildings or vegetation block the Sun.

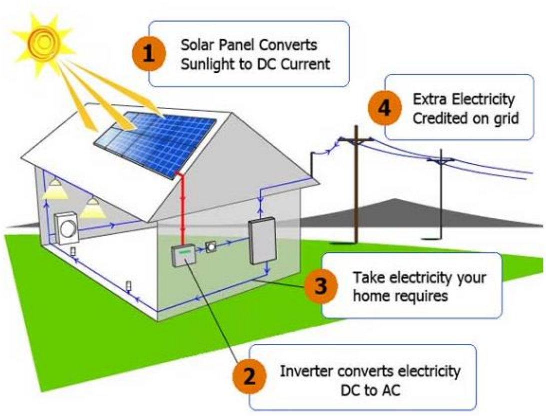

Fig. 2

7.2.1 Potential of solar power to reduce dependence on fossil fuels

- Solar power is a clean energy source that produces no direct greenhouse gas emissions during operation. By transitioning to solar energy, countries can mitigate the environmental impacts associated with conventional fossil fuel-based power generation. The **reduction in carbon emissions** supports efforts to combat climate change and promotes a more sustainable and secure future.
- Solar power derives energy from the sun, which is an **abundant and renewable resource**. Recall from **Lect 5** that solar energy is infinitely renewable. This means that solar power can provide a consistent and sustainable source of energy for the long term, reducing dependence on finite fossil fuel resources.
- Solar panels have also benefitted from production technology advances, which have made it **cheaper and easier to produce** these panels. As can be seen in **Fig. 3**, the prices of electricity from solar are now just as competitive as electricity derived from fossil fuels.

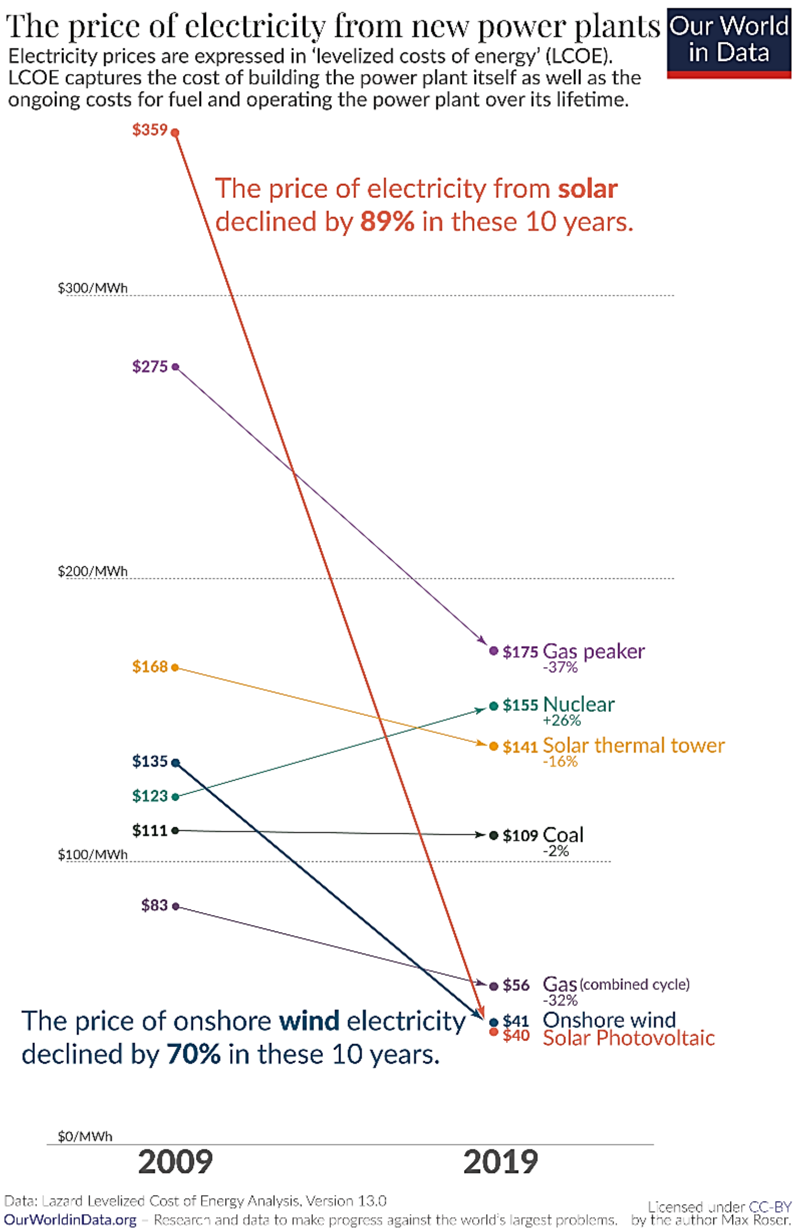

Fig. 3

- Solar power enables **distributed generation**, which means that energy can be generated and utilised at or near the point of consumption. Solar panels can be installed on rooftops, open spaces, or integrated into buildings, allowing electricity to be generated closer to the point of consumption. This reduces the reliance on centralised power plants that run on fossil fuels, and long-distance transmission lines, making the energy supply more resilient and less susceptible to disruptions, enhancing energy security.
- Solar power can help **reduce dependence on imported fossil fuels**. Many countries rely heavily on foreign energy sources, which can create economic and geopolitical challenges. By harnessing solar energy domestically, countries can significantly reduce their reliance on imports and enhance their energy independence.

7.2.2 Limitations of solar power in providing energy security

- While solar energy is limitless in supply, it stills **lacks consistency and reliability**. The following factors limit the availability of sunlight:
  - **Latitude**. Although solar power is an option almost anywhere on the planet in at least some capacity, efficacy falls sharply as distance from the equator increases. Residents of Vancouver, Canada, for instance, are at a significant solar disadvantage compared to Riyadh, Saudi Arabia.
  - **Clouds**. Clouds diminish the power of solar panels, especially in habitually foggy or overcast regions. Even in Singapore, despite our location near the equator, the amount of solar energy we can receive fluctuates depending on changes in cloud cover during the day.
  - **Night.** The most efficient solar panels cannot work without solar energy, so solar panels become inactive and stop producing energy at night.
- The physical limitations of solar panels:
  - **Size**. While residential homes can rely on a small number of panels, to power an entire building, a large solar array is required to compensate for the inefficiencies of single panels. A bulky mechanical orientation system may also be required to turn the panels as they follow the sun across the sky. Batteries, too, can take up a fair amount of space.
  - **Panel deterioration.** Like anything else left out in the sun, solar panels gradually become damaged by ultraviolet radiation. Rain, snow, dirt, temperature fluctuations, hail and wind also pose serious hazards.

Refer to **Reading 1** for why solar energy has yet to take off in a big way in Singapore.

7.2.3 Trade-offs associated with solar power

(a) Economic considerations

- While it is true that the price of electricity from solar power has decreased over time (see again **Fig. 3**), the **initial cost** to setup and install solar panels can be high. The cost of installation will vary based on several factors. The most important being the **number of solar panels** being installed. The cost of a solar installation in Singapore ranges from S$15,000 to S$36,000 or more. A good estimate will be S$20,000 as most residential solar panel systems are around 10 kWp (S$2,000/kWp). *(kWp stands for kilowatt 'peak' power output. For example, a solar panel with a peak power of 8kWp which is working at its maximum capacity for one hour will produce 8kWh*.)

Fig. 4

(b) Environmental considerations

- **Resource extraction, land degradation and habitat loss**
  - The production of solar panels involves the extraction of raw materials, such as silicon, silver, and rare earth metals. The **mining and processing** of these materials can have severe environmental impacts, including land degradation and habitat loss (more in **Lect 9**).
  - Depending on their location, **larger scale solar facilities** may involve **clearing of land** to create the necessary space. However, land impacts from utility-scale solar systems can be minimized by siting them at lower-quality locations such as brownfields, abandoned mining land, or existing transportation and transmission corridors.
- **Pollution**
  - Solar panels have a lifespan of 25 to 30 years or more, after which they need to be properly disposed of or recycled.
  - Solar panels can be considered as **hazardous waste**, due to the small amounts of heavy metals (cadmium, lead, etc.) they contain. Cadmium, for example, when sealed inside solar panels, is harmless. If leaked from the panel, cadmium can inflict serious environmental damage. Panels must be disposed of with extreme care in order to keep this carcinogenic (i.e. cancer-causing) substance from leeching into soil and water.
  - However, the recycling infrastructure for solar panels is not yet well-established everywhere, and improper disposal can lead to environmental contamination. In the United States, by 2035, discarded panels could outweigh new units sold by 2.56 times. Yet it has also been estimated that the cost of recycling one panel is $20-$30, but sending that same panel to a landfill costs a mere $1-$2. Putting these estimates together, the potential environmental pollution could be phenomenal in time to come.
- **Water use**
  - Solar PV cells do not use water for generating electricity. However, as in all manufacturing processes, **water is used to manufacture solar PV components**.

- **Solar plants also require water for cooling.** Water use depends on the plant design, plant location, and the type of cooling system. Plants that use wet-recirculating technology with cooling towers withdraw between 600 and 650 gallons of water per megawatt-hour of electricity produced. There exists other technologies but a solution that is low cost, high efficiency with low water consumption has yet to be found.

- **Life-cycle global warming emissions**
  - While there are no global warming emissions associated with generating electricity from solar energy, there are emissions associated with other stages of the solar life-cycle, including manufacturing, materials transportation, installation, maintenance, and decommissioning and dismantlement.
  - Most estimates of life-cycle emissions for photovoltaic systems are between 0.03 and 0.08 kg of carbon dioxide equivalent per kilowatt-hour. However, this is far less than the lifecycle emission rates for natural gas and coal.

(c) Social considerations

- **Workers' exposure to hazardous materials**
  - The PV cell manufacturing process includes a number of hazardous materials. Workers also face risks associated with inhaling silicon dust. Thus, PV manufactures must ensure that workers are not harmed by exposure to these chemicals and that manufacturing waste products are disposed of properly.
- **Employment transition**
  - As the adoption of solar power increases, it can lead to job losses in traditional energy sectors, such as coal mining or fossil fuel power plants. Supporting a just transition for affected workers through retraining programs and new employment opportunities is essential to address potential social and economic disruptions.

7.3 Hydropower

- Hydropower, or hydroelectric power (HEP), currently supplies 16% of global electrical demand (but only 6% of global energy demand). The most common type of HEP plant uses a dam on a river to store water in a reservoir. Water released from the reservoir flows through a turbine, spinning it, which in turn activates a generator to produce electricity (see **Fig. 5**).

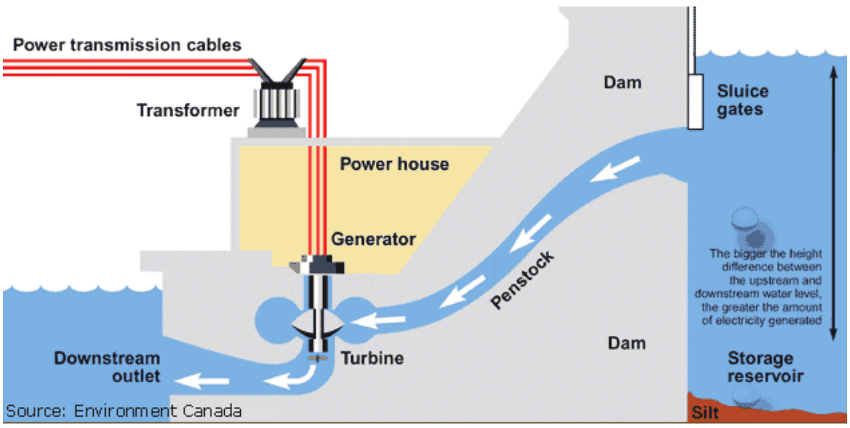

Fig. 5

7.3.1 Potential of hydropower to reduce dependence on fossil fuels

- **Hydropower energy has the highest energy payback ratio compared to other renewable source of energy.**
  - This can be reflected by the increase in hydraulic efficiency over the years, with modern equipment reaching 90-95% efficiency. Therefore, cost per unit output of energy is the lowest among other sources of renewable energy.
  - As such, this provides a strong incentive for countries to substitute non-renewable sources of energy for hydropower energy. Countries such as Brazil, Norway and even Ethiopia harness hydropower energy significantly, with the share of hydropower in their primary energy mix being at least 80%.
- **Hydropower energy can be generated quickly in response to fluctuations in energy demands.** This is especially so for hydropower dams that are built in front of a reservoir. Given the unpredictability of energy demands, having a source of readily available energy supply will ensure the energy security of the country.
- **Hydropower energy leaves a much lower carbon footprint than non-renewable sources of energy.** The actual process of energy generation does not produce significant carbon dioxide emissions. By using water as drivers of energy turbines, no combustion of fuels is required, which allows hydropower to be a much cleaner source of energy than non-renewables.
  - The construction of the Three Gorges Dam in China opens the possibility for hydropower to be the second energy source after coal in China's energy mix. This greater reliance on hydropower has enabled China to reduce her burning of more than 30 million tonnes of coal annually, reducing its carbon dioxide emissions drastically.

7.3.2 Limitations of hydropower in providing energy security

- **The potentials of harnessing hydropower energy are also dependent on the suitability of sites within the country.** In smaller countries that are largely scarce of natural resources, especially those who lack the presence of natural rivers, it is extremely difficult to construct hydropower plants that are able to contribute significantly to the country's energy mix.
  - For example, Singapore is scarce of water bodies that are suited to generating cost-efficient hydropower energy. As a result, she is inclined towards relying on energy generation methods that are not limited by land space. Therefore, it is no surprise that natural gas contributes to 95% of its electricity generation.

7.3.3 Trade-offs associated with hydropower

(a) Economic considerations

- **The start-up costs of hydropower dam, especially large-scale ones are extremely high.**
  - This may make dam construction unsuitable for developing countries that lack financial resources. According to the International Energy Agency, the top 10 producers of hydropower energy in 2012 are also among the top 30 economies in the world, with the lowest ranking country being Venezuela. Therefore, the suitability of implementing dam

construction projects in Africa, the continent with the greatest untapped hydropower potential, may be severely limited by financial restrains.

- Additionally, the river course is altered during the process of establishing reservoirs which requires the resettlement of affected communities (see **(c)** later). All these contribute to the high costs of hydropower dam projects as reflected by the estimated US$88 billion that China had to commit in order to construct its Three Gorges Dam.

(b) Environmental considerations

- **Hydropower energy is not as clean as it seems.** The construction, operation, maintenance and dismantling of hydropower plants contributes to life-cycle greenhouse gas emissions. (However, these are one-two orders of magnitude lower than the life-cycle GHG emissions from fossil fuels)
  - Other sources of GHG emissions of hydropower:
    - decomposition of pre-existing biomass at the bottom of reservoirs, generating methane and carbon dioxide in the water (a study found that when considered over a 100-year timescale, dams produce more methane than rice plantations and biomass burning);
    - loss of carbon sinks (e.g. wetlands and forests) due to alteration of flow patterns and land use.
- **The construction of dams alters the rivers' ecology and other natural characteristics. (See Fig. 6)**
  - A pertinent issue in dam construction is the potential disruption it can cause to the migration cycles of fishes in the river. This is due to dam serving as blockage along the river course. After the construction of the Three Gorges Dam, species such as the Chinese paddlefish were identified as endangered as they faced difficulty in migration.
  - This blockage also affects the flow of sediments and debris downstream, potentially leading to the deposition of sediments in the reservoir. The Yangtze river experienced a 50% decrease in the amount of sediments collected at the river mouth after the construction of the Three Gorges Dam. This had adverse impacts to the Yangtze river's chemical composition and geomorphology and largely made it uninhabitable for the Chinese River Dolphin, as reflected by its extinction.

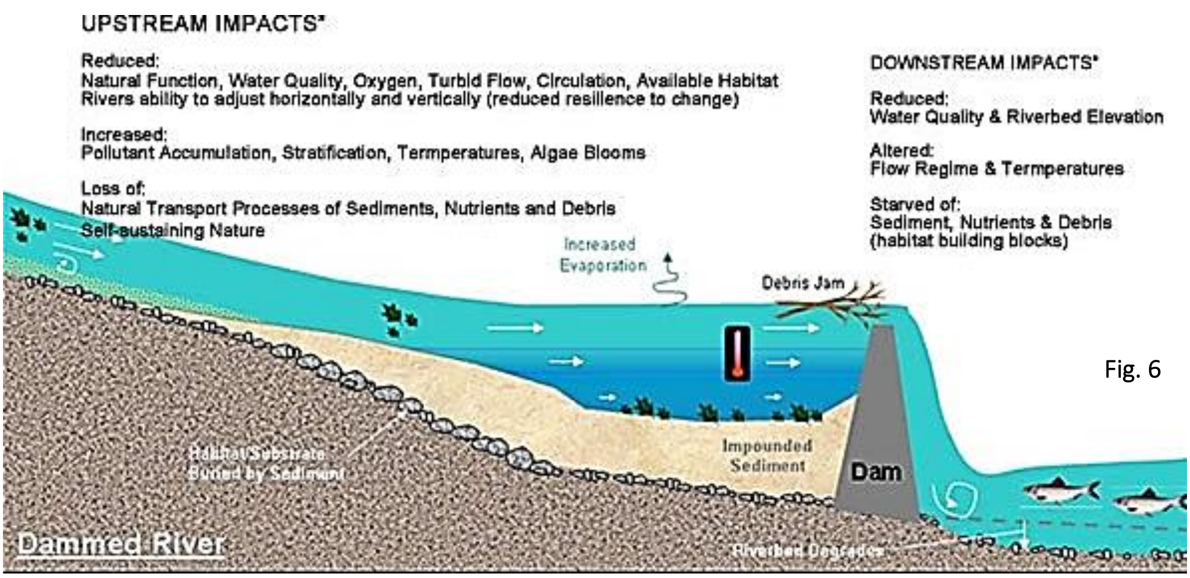

Fig. 6

(c) Social considerations

- **Construction of hydropower dams can lead to disruptions to the lives of people living along dam sites.** The implementation of large-scale dam projects often requires large amounts of land. More often than not, these lands may be home to the indigenous communities. Therefore, this leads to their displacement and subsequent resettlement.
  - During China's Three Gorges Dam project, 1.3 million people were displaced and many farmers were relocated to marginal lands with less fertile soils. (See **Fig. 7**)
  - Additionally, many who worked in manufacturing experienced cultural barriers within their new settlements and faced difficulty in finding new jobs.
  - Also, harnessing hydropower through the construction of reservoirs may lead to the opportunity costs of losing noteworthy landmarks near the river banks. Sacred cultural sites and precious fertile farm land were compromised in order to complete the Three Gorges Dam. This led to the loss of places of interests to attract tourists as well as agricultural potential of the land.

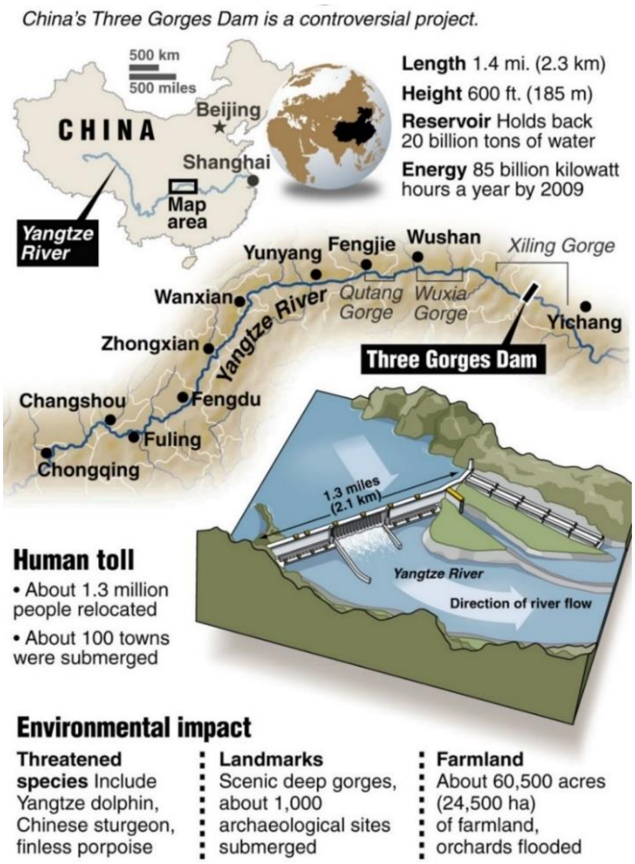

Fig. 7
At the time of completion in 2006, the Three Gorges Dam was the world's largest dam, and remains one of the largest today.

Refer to **Reading 2** for the range of impacts the generation of HEP in Laos has brought.

Table 2. Advantages and Disadvantages of Solar power and Hydropower

	Advantages	Disadvantages
Solar	• Pollution free (except for production and disposal of solar panels) • Plentiful silica resources (to make solar panels) • High reliability, no moving parts • Relatively cheap and efficient • Good potential in less developed countries	• Intermittency of solar intensity • Ineffectiveness of storing the energy generated, so limited uses • Use of some toxic materials in pv cell production • Grid connection challenges
HEP	• Low operating costs • No waste or CO_2 emissions • Proven technology • Can top-up supply in periods of peak demand	• Dams have high construction costs • Requires large amounts of land so causes conflict, for example, relocation of populations • Environmental impacts on drainage basin and microclimate effects

Reading 1

Commentary: Why hasn't solar energy in Singapore taken off in a big way after so long?

Transitioning to solar energy will support Singapore's climate change mitigation goals but cloud cover, space constraints and technological constraints pose challenges, says NUS Energy Studies Institute's Philip Andrews-Speed.

04 May 2021 CNA

SINGAPORE: In 2016, the Government issued its Climate Action Plan which included a commitment to reduce the intensity of greenhouse gas emissions by 36 per cent from 2005 levels by 2030, and for these emissions to reach a peak at around 2030.

Early last year, it made a further commitment, aiming to halve the level of peak emissions by 2050 and achieve net-zero emissions "as soon as viable in the second half of the century".

Among other measures, this will require the country to reduce its dependence on fossil fuels, notably in the production of electricity where more than 95 per cent is produced by natural gas.

Singapore's options for domestically generated low-carbon electricity are relatively limited.

There is insufficient wind for wind power, the rocks beneath us are not hot enough for commercially viable geothermal energy.

Tidal and wave energy have theoretical potential but Singapore's maritime space is too busy with shipping, and nuclear energy is considered too risky for Singapore even with today's technology

Therefore, solar energy is the most viable option and solar photovoltaics is the current prevailing technology. This why the Minister for Trade and Industry Chan Chun Sing in October 2019 identified solar energy as one of the "Four Energy Switches".

Solar energy also improves the country's security of energy supply as it is produced within Singapore. In contrast, all natural gas is imported.

Solar photovoltaic panels (or modules) consist of a number of cells composed of semiconducting materials that convert sunlight into electricity through what is known as the photovoltaic effect.

Although the mass production of photovoltaic cells dates back 40 years, the extensive deployment of solar photovoltaic panels around the world only really started to pick up from about 2010.

Since then the global installed capacity has risen 17-fold. One of the reasons for this recent surge of capacity is that the cost of photovoltaic panels has declined to about one-tenth of what it was in 2010.

Singapore's deployment of solar photovoltaic panels at significant scale started in about 2009 and accelerated from 2015.

By September 2020, the total installed capacity was 400 MWp (MWp is the power output of a solar power system which would be achieved under ideal conditions).

But this is still only a tiny fraction of the country's total power generating capacity of 12,600 MW. Furthermore, solar power is variable unless accompanied by energy storage and so it contributed only about 0.55 per cent of the country's total electricity supply in late 2020.

The current objective is to boost the installed capacity of solar photovoltaics to 2,000 MWp by 2030. This would provide the equivalent of 4 per cent of Singapore's electricity at today's level of demand.

But, of course, the country's demand for electricity is likely to continue growing, not least as we electrify road transport.

This leads to the question of why these ambitions are so modest.

THE PROBLEM WITH CLOUD COVER

The constraints to Singapore's ability to host a substantial solar photovoltaic capacity arise primarily from the limited availability of two natural resources about which we can do little: Sunlight and space.

On top of these are a number of technological issues that can be progressively addressed.

Although Singapore's climate is relatively hot and the weather is usually sunny, the average intensity of solar radiation across a full year is not very high. Certainly it is 50 per cent higher than that in northern Europe where solar photovoltaic plays a significant role, notably in Germany.

However, it is significantly less than that in northern China, and 30 to 40 per cent less than in the deserts of North Africa, the Middle East and Australia where vast solar photovoltaic arrays are being constructed.

Singapore's problem is cloud cover and humidity, as it is across much of Southeast Asia. In addition, the consistently high temperatures reduce the efficiency of photovoltaic cells.

SINGAPORE DOESN'T HAVE ENOUGH SPACE

Space is the second key constraint. Singapore lacks vast open spaces in which to build large solar arrays. Much of the land here is occupied by buildings, roads and protected green spaces.

Today about one third of the country's solar energy capacity sits on the rooves of residential buildings, while most of the rest is on public space developed by town councils and grass root units. Industrial buildings account for only just over 10 per cent of this capacity.

Last year saw the publication of an updated roadmap for solar photovoltaic energy produced by a consortium led by the Solar Energy Research Institute of Singapore (SERIS).

This detailed analysis concluded that the total usable space for solar photovoltaic panels amounted to just under 37 sq km.

Of this, 62 per cent would be on buildings, both roof space and facades. The balance would be shared between temporary land-based installations (temporary because the land is zoned for other uses), floating installations on reservoirs and unused near-shore sea areas, and panels installed above land, canals and roads.

Costs will vary between the options, and none are cheap compared to installing arrays on large tracts of unused, open land. This is an important consideration given that Singapore runs a competitive electricity market. However, as the national price of carbon rises, the commercial viability of these options will improve.

TECHNICAL CONSTRAINTS

The three technical constraints relate to cell efficiency, energy storage and grid integration. The efficiency of commercially available photovoltaic cells currently lies in the range 15 to 21 per cent.

What is also important is that some of the more efficient technologies lose less efficiency as temperatures rise. Looking to the future, we should expect new cell designs to have higher efficiency.

As the total capacity of solar photovoltaics grows, energy storage becomes important. This is because solar energy varies during the day as well as from day-to-day.

Although demand for electricity in Singapore is high from 9am to 5pm when the sun is at its highest, there is also a lower peak of demand in the evening when people return home from work and turn on their air conditioners and other electrical devices.

Batteries and other forms of energy storage will be increasingly needed as the country's use of solar energy rises to provide electricity in the evenings.

Energy storage will also help with integrating the solar power into the electricity grid. The variability of solar energy, from minute-to-minute as well as from hour-to-hour, can pose challenges to maintaining grid stability as the amount of solar power generated rises.

This should not be a problem in Singapore due to flexibility of the gas-fired power stations, especially if they are backed up by energy storage systems.

LIFESPAN OF SOLAR PANELS, EFFECTS OF CLIMATE CHANGE KEY UNCERTAINTIES

Looking to the longer term, two other issues are relevant. First, the life span of solar panels is generally 20-25 years, if well maintained.

This compares to 40 years for a gas-fired power station. The panels will then need to be replaced and the materials recycled.

Less easy to manage will be possible effects of climate change. Temperatures in Singapore may continue rising which will lower the efficiency of the cells, cloud cover and humidity may increase, and the frequency of powerful storms may escalate.

In summary, there are severe limits to Singapore's ability to generate significant quantities of electricity from renewable sources, and this will not come without a cost.

Nevertheless, the Government is determined to make this effort. However, if the country wants renewable energy to supply a substantial share of its electricity, then this will have to be imported either from mainland Southeast Asia or from Australia.

This takes us back to the announcement in October 2020 by Mr Chan that Singapore would import electricity from Malaysia, starting with a two-year trial.

While this is a nice start, access to substantial quantities of renewable energy will require drawing in hydroelectricity from Laos. Plans also exist to build a cable to bring solar energy from Australia to Singapore.

As a result, Singapore will become increasingly dependent on imported renewable energy rather than natural gas for its electricity supply, though gas is likely to remain important for any years.

Philip Andrews-Speed is Senior Principal Fellow at the Energy Studies Institute, National University of Singapore.

Reading 2

The cost of Laos' quest to be Southeast Asia's 'battery', and the World Heritage town at risk

Laos, which bet big on hydropower to draw foreign investment, supplies electricity to several countries but is swimming in a sea of debt. A dam near its ancient capital has become another cause for worry, the programme Insight finds out.

30 Oct 2022 CNA

VIENTIANE: With electricity exports to Thailand, Vietnam, Cambodia, Myanmar, Malaysia and even Singapore, Laos has arguably realised its ambition to be the battery of Southeast Asia.

The bulk of these exports are from hydropower. Nearly 80 dams dot the landlocked country, and more along the Mekong River are in the pipeline, including one that lies 25 kilometres from the Unesco World Heritage town of Luang Prabang.

Slated to be completed in 2027, the Luang Prabang dam will have an installed capacity of 1,460 megawatts — more powerful than Laos' other dams — with much of the energy to be sold to Thailand.

The main site of the dam has been cleared, and the project has brought more business to local boatmen such as Thid Pheu, who ferries workers to and from a village near the construction site.

"We make more money when the construction needs more workers, because we charge 20,000 kip (S$1.63) per person," Thid said, adding that six boats, out of 64 in total, provide this service each day.

"It's beneficial for people who live in the countryside with little money. If they own a boat, they can earn money from transporting people back and forth."

The risks involved with the project, however, have become a cause of worry about how it could affect safety, heritage, the environment and other segments of the community.

Laos' dams will help Southeast Asia meet its growing energy demand without adding to its carbon emissions; indeed, hydropower accounts for the largest share of global renewable energy capacity, helping countries reduce their reliance on planet-warming fossil fuels.

But at what cost, the programme Insight finds out.

"There's a lot of concern over the Luang Prabang dam — that it'll impact people's livelihoods and even the World Heritage values of the town," said University of Sydney emeritus professor of human geography Philip Hirsch.

It will sit between Pak Beng, another dam being planned upstream, and the downstream Xayaburi dam. It is being developed by PetroVietnam Power and CK Power, a subsidiary of Thai construction firm CH Karnchang.

"By creating a reservoir that's about 60 to 70 km long, and whose tail-end will be at the point where the next dam upstream is going to be built … you've changed the river from a flowing entity to a series of steppe lakes," said Hirsch.

The construction of Luang Prabang dam will result in the relocation of 26 villages comprising almost 10,000 people. Such areas where dams are located do not have good infrastructure, said Chanthaboun Soukaloun, managing director of state-owned power company Electricite du Laos.

"Sometimes there's no healthcare, no hospitals. Sometimes the road access to the village (is) only in the dry season," he said. "When we have the resettlement plan, it'll help (people) improve their livelihood instead of … (making) them poorer."

Hirsch, however, said his research "in communities affected by dams" has shown otherwise.

"I've never found a community that's been displaced by a dam that's been able to re-establish its livelihood, its way of life, its incomes to a level which they had before the dam was built," he said.

Thousands of people previously displaced by two other dams in the province were resettled in government-built villages elsewhere. And resettlement brings certain benefits, he acknowledged.

Luang Prabang, the country's ancient capital, is also sited in a zone with fault lines and the potential for earthquakes, he said. This gives rise to concerns about dam safety and the safety of people living nearby.

Laos has experienced dam collapses in the past. In 2018, an auxiliary dam of the Xe Pian-Xe Namnoy hydropower project collapsed owing to construction flaws, which killed 49 people, left 22 missing and displaced at least 7,000 others.

Not many people know that two other dams in Laos collapsed before this incident, said Hirsch. To his knowledge, they did not lead to loss of life.

FAR-REACHING ECOLOGICAL EFFECTS

Without proper data, monitoring and stakeholder engagement, hydropower projects can disrupt both communities and ecosystems. This is already apparent along the Mekong, Southeast Asia's longest river, which supports the livelihood of over 50 million people.

The 1,285-megawatt Xayaburi dam has led to a lack of irrigation water in Thailand's Nong Khai province, 400 km downstream. Farmers must extend their pipes to pump water from the river when its level falls, said villager Vinai Phrompaksa, 60.

And when water is released, it is usually very rapid. Vinai said he "lost everything" last year when his rice field was flooded.

His chilli and eggplant crops were also destroyed, as was his tobacco farm. Farmers like him practise crop rotation, which includes growing tobacco after harvesting rice, he said. He lost 40,000 baht (S$1,490) to 50,000 baht in total. In an unstable situation, people will quit farming if floods happen too often, he added.

Damming the Mekong River also puts the fertility of agricultural lands at risk. The dams collect sediment and prevent this "natural fertiliser" from reaching the Mekong Delta, cited Hirsch.

If the plans to develop hydropower on the Mekong go ahead, it is predicted that more than 90 per cent of the sediment would no longer reach the delta by around 2040, he said.

"We're looking at a river that normally would carry 160 million tonnes of sediment down the Mekong delta." This would affect both Thailand and Vietnam, two of the world's biggest rice exporters, noted the Mekong River Commission Secretariat's chief executive officer, Anoulak Kittikhoun.

The ecological effects are far-reaching indeed, as the Mekong River flows through six countries, stretching as far as 4,900 km from its source in the Tibetan Plateau in China.

In 2011, when preparatory construction on Xayaburi dam started, protestors gathered outside the Lao embassy in Bangkok calling for a halt to the project. The dam would damage the Mekong ecosystem in north-western Thailand, they said.

Villagers also filed a lawsuit against Thai government agencies including the Electricity Generating Authority of Thailand, which was to buy the bulk of electricity generated by the dam.

But they lost, and Laos' largest existing dam was completed in 2019, funded by six Thai banks and built by a Thai company.

Ormbun Thipsuna, a representative from the Northeast Community Network in Seven Provinces of Mekong River Basin, recalled a day in July 2019 when the dam was undergoing tests and the river "suddenly dropped four metres in one night".

Villagers were not given any warning, and many of the fish farms saw their fish die, she said.

Dams "tend to stop and start", said Hirsch. They generate electricity during peak demand, then hold back water at night, when people are not using as much power.

This means people living downstream experience "much greater fluctuation (in water levels) on a daily basis or even hourly basis" than they would naturally.

Nong Khai fisherman Boonrueng Bootseethat, 67, said: "The river has changed, and the fish are disappearing."

Upstream fishermen have been affected too. In the Laotian village of Chom Ngua, 27-year-old Hieng Xayaxavanh has fished for 14 years and used to catch 10 kilogrammes of fish a day but can barely catch 1 kg now.

"We used to catch big fishes such as giant catfish and shark catfish. But now we can't catch them because they can't swim past the (Xayaburi) dam," he said.

Fisherman and farmer Sengathid Dalaphone added: "It's difficult for the fish to swim up and lay eggs."

Most of the Mekong River's fishes are migratory, but with a dam structure in the river, the fish are "no longer able to complete their life cycle", said Hirsch.

By 2040, if "numerous dams" are built on the river and its tributaries as planned, the Mekong basin's fisheries will see a 40 to 80 per cent decline, added Gary Lee, the Southeast Asia programme director of non-governmental group International Rivers, citing a study by the Mekong River Commission, an intergovernmental organisation.

INVESTORS BENEFITING MORE THAN CITIZENS?

Why did Laos decide to develop hydropower in the first place? To attract foreign direct investment and open the

Lao market to the outside world, said its minister of energy and mines, Daovong Phonekeo.

More than two thirds of its current hydropower capacity in operation is exported, and he said the power sector's contribution to Laos' gross domestic product (GDP) is approaching 15 per cent.

"We have to use our natural resources to bring more prosperity," he said, adding that hydropower development has also "helped directly" to increase the electrification rate from about 30 per cent before 2000 to about 95 per cent of households.

The country's National Assembly has approved a strategy of deriving 75 per cent of electricity from hydropower and 14 per cent from coal by 2025, with the remainder coming from sources like solar and biomass, he said.

On why coal, the dirtiest fossil fuel, has crept into the energy mix — only since 2015 — he said: "We don't have any oil, any gas, but we have quite a large amount of coal. "It'll help to stabilise the (electricity) supply."

During the dry season, when Laos experiences an energy deficit, it buys back what it has exported to Thailand. But this is at about twice the initial sale price, which does not make economic sense, said Lee.

"Laos should reconsider its strategy and its reliance on large-scale hydropower development as a means of revenue generation," he urged.

The country's hydropower push carries another cost: Large-scale hydropower projects require borrowing, and the "rapid development" of dams has been a "significant factor in the growing levels of debt in Laos", he said.

Laos' public debt levels have "increased considerably" since 2019, reaching US$14.5 billion (S$20.5 billion) last year and endangering its macroeconomic stability, the World Bank stated in April.

Public and publicly guaranteed debt increased to 88 per cent of GDP, with the energy sector accounting for over 30 per cent of the debt stock, "while the share of commercial debt has increased, adding pressure to liquidity management".

In 2020, Laos also sold its electricity transmission grid to a Chinese state-owned enterprise for US$600 million in an apparent debt-for-equity swap.

It is clear to Hirsch that dam-building has not been a real economic solution for Laos.

"Much of the money that's being made from dams is actually being made by the investors. It's not really going to improve the well-being of the Lao people," he said.

"Laos needs to take a break and to ask what's actually beneficial for the majority of the Lao population, not just for the facts and figures of how much foreign investment (it's) able to attract."

Chanthaboun acknowledged the energy sector's debt and said Electricite du Laos has "invested a lot" in power transmission and substations to give Lao citizens — spread over a "quite large" land area — access to electricity.

The government has asked it to address the issue, said the managing director. "We have to be more efficient, and our additional investment in future has to be carefully reviewed to ensure that (it can) service the debt by itself." The company is also looking at other forms of clean energy.

He said its current solar capacity is about 80 megawatts, while Laos also has "quite large" wind power potential, especially near the Vietnamese border. He cited a 600-megawatt wind farm being developed, which will supply power to Vietnam.

Watch this episode of Insight below (Scan QR code)

Article	Video

https://www.channelnewsasia.com/cna-insider/cost-laos-hydropower-quest-southeast-asia-battery-electricity-dams-risk-3029086