



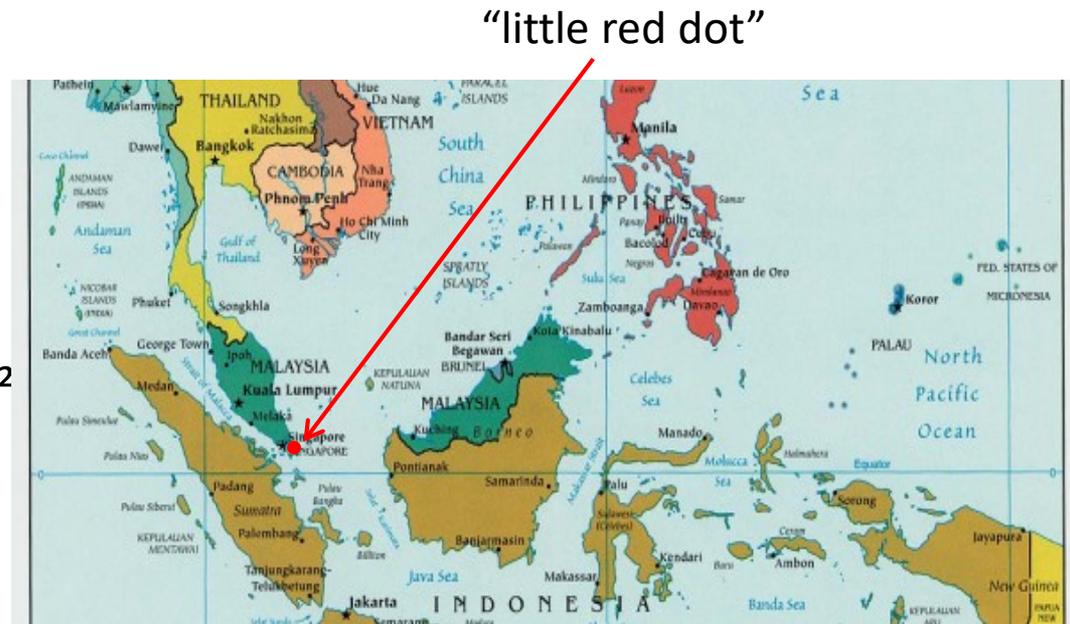
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Energy Efficiency and its Contributions to Mitigating Singapore's GHG Emissions

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Facts about Singapore:

- Urban city-state of just 719km² (50km W-E x 26km N-S)
- Tropical climate on equator
- Low-lying, gentle topography, highest point 164m
- Population: 5.54 million in 2015
- Population density: 7,700 per km²
- GDP: S\$402 billion in 2015
- Per capita GDP: S\$73k; ~56k USD
- Contribution to global emissions: 49 MtCO₂e in 2012
< 0.2% of global emission
- Per capita emissions: ~12.49 tCO₂/person in 2011
(Ranked 15th in 2011 by WRI CAIT 2.0)
- Electricity generation capacity: ~ 13 GW (97% from natural gas)

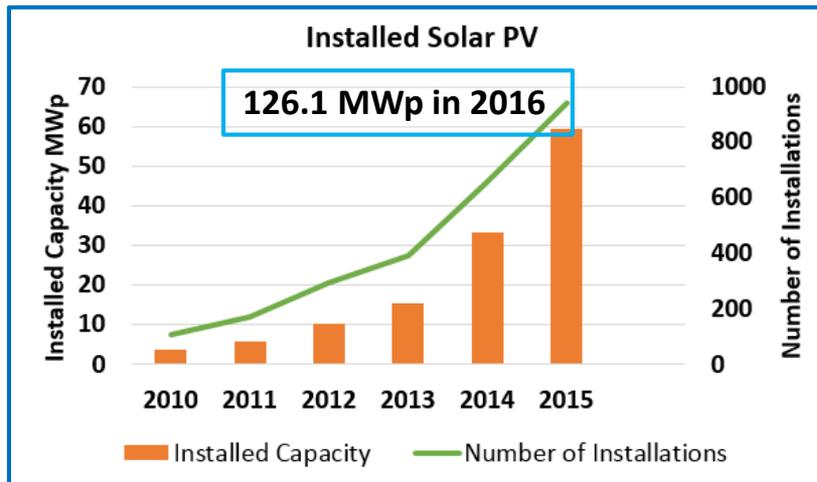


Singapore's Limited Access to Alternative Energy Sources

Small size and dense urban landscape: challenges to using alternative energy sources such as solar and nuclear; also limit our access to geothermal resources, hydroelectricity, wind, tidal and wave power.

- **Biomass:** municipal wastes - 2% of our electricity needs; a few small-scale waste wood cogeneration power plants
- **Geothermal:** No geothermal resources. Minute geothermal resources cannot be utilized in a cost-effective manner with current technologies.
- **Hydroelectric:** Singapore is flat and less than 15m above sea level, no major river systems.
- **Tidal and wave power:** The tidal range is about 1.7m, well below the 4m tidal range for commercial tidal power generation; wave power from surrounding waters is also limited.
- **Wind:** Wind energy is also not viable, low average wind speeds of about 2m/s to 3m/s and lack of land for large-scale application of wind turbines. Most commercial wind farms leverage average wind of at least 6m/s.

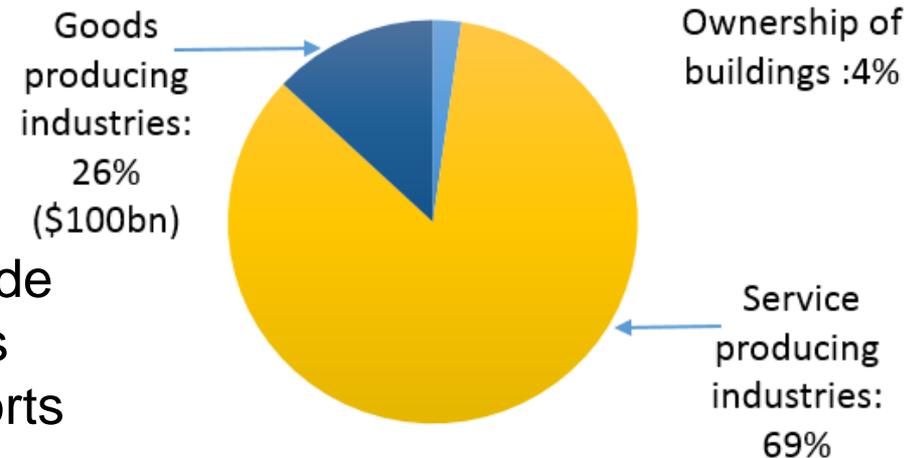
- **Nuclear:** Given that the country is small and densely populated, outweigh the benefits at this point; nuclear energy technologies presently available are not yet suitable for deployment in Singapore.
- **Solar energy:** The most viable source of renewable energy; even though there are space constraints due to compact and dense urban landscape. Singapore has been exploring ways to increase our use of solar energy.
- Announced target of 350 MWac for 2020 was raised to 650 MWac in 2014.



Singapore Economy

- Rapid economic development in the past few decades.
- Manufacturing sector: ~ 20% →
- Singapore is highly dependent on international trade, total external trade was S\$884.1 billion, about 2.2 times GDP, with S\$476.3 billion from exports and S\$407.8 billion from imports.
- The main imports were Petroleum & petroleum products, chemical and chemical products, and electronics, accounting for 22%, 8% and 29 % of the total imports. The contributions of these three commodities accounted for 17%, 14% and 35%, respectively, of the total exports.

Singapore 2015 GDP \$402 Billion



Singapore Final Energy Consumption in 2012(ktoe)

Year 2010	Coal and Peat	Petroleum Products	Natural Gas	Electricity	Others	Total
Total Final Energy Consumption	23.1	7,946.8	1,255.5	3,800.6	—	13,026.0
Industry-related	23.1	5,562.0	1,092.2	1,596.6	—	8,247.2
Transport-related	—	2,292.7	22.2	200.2	—	2,515.1
Commerce and Service	—	68.3	83.5	1,407.2	—	1,599.0
Households	—	23.7	56.9	570.0	—	650.6
Others	—	—	0.8	26.1	—	26.9

Singapore's greenhouse gas emissions grew at a CAGR of 2.0% from 2000 to 2012. The total GHG emissions in 2012 was 49 Mt CO₂e (< 0.2 % of the world total): 42.5% came from the energy and energy transformation industries, 38.8% came from industry and 15.9 % came from transport sector.

Challenges to GHG Reductions

- 2009 Copenhagen pledge: reducing emissions by 16% below 2020 levels
- Under PA, committed to reduce its GHG emissions intensity (per unit GDP at 2010 prices) by approximately 36 per cent as compared to 2005 levels by 2030, and aim to peak around 2030.
- 36% EI reduction and stabilization of emissions are challenging targets under national circumstances: dense population and small land area.
- GHG mitigation action would have to come from the industry, buildings (commerce & service) and transport sectors: **Improving energy efficiencies is the key strategy.**

Industry sector Energy Use and Emissions

In 2012, the primary energy consumption (mainly petroleum products and natural gas) of the manufacturing sector which contributed about 19% to the GDP, was 6,659 ktoe: 51% of Singapore's total final energy consumption and about 18.6 million tonnes CO₂ emissions.

Incentives and grant schemes

- Productivity Grant (Energy Efficiency) 20% of qualifying costs capped at \$4 million per project to invest in energy efficient equipment and technologies;
- Design for Efficiency Scheme (DfE), 50% of the qualifying costs or \$600,000 with the objective of encouraging new facilities or expansion projects to integrate energy efficiency improvements in the design stage;
- For SMEs, a budget of \$17 million under SMEEE initiative to help ~ 300 such enterprises achieve at least 10 per cent savings in energy costs.

Singapore industry energy consumption and emissions

Industry subsector	Primary Energy (%)	Emissions (%)
Chemicals	42	33
Petroleum Refining	34	29
Semiconductor	6	16
Pharmaceuticals	1	2
Food and Beverage	3	3
Printing	1	1
Precision Engineering	4	5
Marine and Offshore	2	2
Medical	<0.5	<0.5
Other	7	9

82% of primary energy use and 78% of CO2 emissions.

Building Energy Efficiency

Third largest share of final energy consumption. Singapore has set a target of achieving 80 percent green buildings by 2030.

To achieve this target, Singapore introduced the Building Control Regulations in 2008. Under this law: minimum environmental sustainability standard (equivalent to a “Green Mark Certified” level) is required for new buildings and existing buildings undergoing retrofits or expansions, with a Gross Floor Area of more than 2000 sq. m.

An assessment scheme which evaluates the overall environmental performance of buildings on multiple criteria. Eg: ETTV < 42 W/m²; Cooling eff > 0.8 kW/RT.

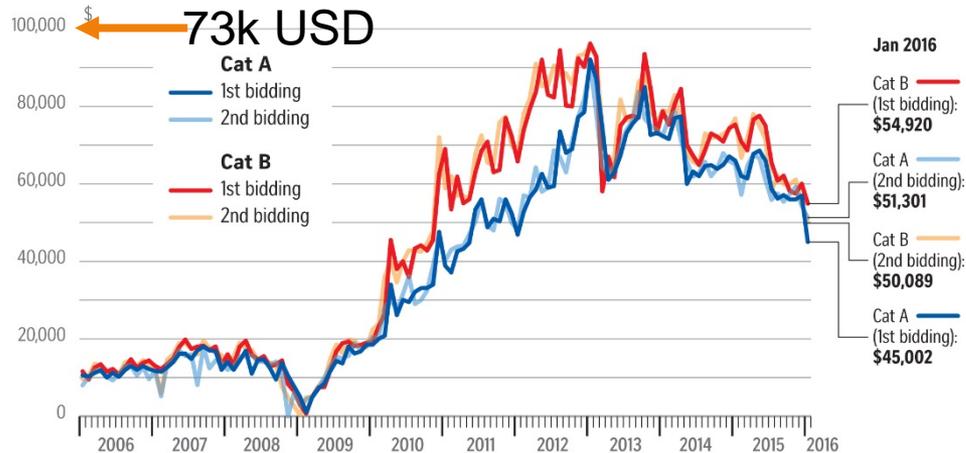
To encourage energy efficient design and equipment in buildings and achieve higher Green Mark ratings, the BCA offers a number of incentive schemes, eg the Green Mark Gross Floor Area scheme: additional floor area of 2 percent to developments that attain Platinum rating.

Transport Energy Efficiency

Measures in place:

- Private vehicle ownership discouraged → high taxes and road use cost
- Private vehicle population control → certificate for purchase (COE)
- Increase in modal share of public transport → 75% by 2030; rail network to 360 km by 2030.

COE premiums over the years



Source: LTA ST GRAPHICS

S\$108,000 or US\$80,000 →



Legislation

The Energy Conservation Act (ECA) 2012 is the primary legislation in Singapore: businesses that use 54 TJ/year or more are required to appoint an energy manager; monitor and report energy use and GHG emissions; and submit energy efficiency improvement plans annually.

Market Mechanisms

In February 2017, the Minister for Finance announced plans to introduce a carbon tax on large direct emitters of GHGs such as power stations and the refining and petrochemical industry. The carbon tax will be implemented in 2019 and the tax level will be between \$10 - \$20 per tonne of direct emissions and covered installations with direct emissions greater than 25,000 tonnes of CO₂e.

Achieving 2020 and 2030 Emissions Targets

2020 Mitigation Target

- Assuming a Business as Usual (BAU) scenario from 2005, it was estimated that Singapore's emissions would reach 77.2 million tonnes (MT) CO₂e by 2020 (NCCS 2012, 43). The 2009 Copenhagen pledge of reducing emissions by 16% below 2020 levels implied a mitigation reduction of approximately 12.35 million tonnes.
- Various government agencies are responsible for implementation, monitoring and documentation of mitigation actions under their purview.
- The projected quantified mitigation goals for each sector to meet the 2020 pledge are given in the Second Biennial Update Report (BUR2) submitted to the UNFCCC in December 2016 (NEA 2016) and are summarized as follows:

Singapore sectoral mitigation goals for 2020

Mitigation Action	2020 Mitigation Goal (MtCO ₂ e)	Results Achieved 2014 (MtCO ₂ e)
Fuel mix switch in power generation	4	4
Solar PV	0.179	0.015
Cogeneration plants	0.73	0.488
Manufacturing energy efficiency	0.4	0.472
Fuel mix switch in industry	0.07	0.07
Data center energy efficiency	0.04	0.00028
Green mark in new buildings	0.47	0.364
Green mark in existing buildings	1.08	0.131
Increasing public transport modal share	0.78	0.38
Off peak vehicles and non-motorised transport	0.2	0.05
Car/Taxi fuel efficiency CEVS*	0.67	0.05
Green Technology Programme**	0.1	0.01
MEPS*** for households	0.79	0.44
Promotion of energy efficiency in households	0.28	0
Wastewater sludge disposal by incineration	0.1	0.08
Increase overall recycling rate	0.05	NIL
Total	9.939	6.550

The goals set for the industry sector in terms energy efficiency and fuel mix switch of 0.47 MT seems modest in terms of the industry sector's total primary emissions of 6.654 MT in 2014 and which also accounts for 1596.6 ktoe or 42% of the total national electricity consumption.

Statement by the Minister for the Environment and Water Resources at UNFCCC COP-22, **Singapore is on track to meet its Copenhagen pledge** (UNFCCC 2016).

2030 INDC target

Singapore's INDC target: reduce emission intensity by 36% in 2030 from 2005 levels and to peak its absolute emissions around 2030 at about 65 million tonnes CO₂e. **Achieving this target will be challenging in the context of Singapore's national circumstances and early action taken in power generation sector.**

- No published data on the total or industry-related BAU emissions levels. A projection of emission levels based on Singapore's 2020 target of 65 MT CO₂e and on CAGR of 2.0 % over a 10-year period estimates the emission in 2030 of 79.3 MT CO₂e. A further assumption of constant share of the industry-level contribution of 42.2 % (2012 share) **gives a projected industry-related emission level of 43.9 MT CO₂e.**

The Roadmap's estimated reduction potential indicates a reduction level of about 9 MT in 2030 for the industry sector.

- For the buildings sector, the major improvement in energy efficiency will be achieved by ensuring that all new buildings conform to the requirements of the Green Mark standard and that the existing building stock is also retrofitted to be energy efficient in an organized manner.

In a short time since the Green Mark was introduced, already 31% of Singapore's entire building stock has conformed to the standard.

- Transport sector: expected to achieve a 75% modal share of public transport by 2030. Current policy to curb the growth of vehicle population and discourage use of private transport through heavy taxation and limited availability of car ownership certificates have worked well and would be supplemented by high vehicle taxes and fuel duties.
- The power generation: 43% of the total emissions, reducing emissions in this major sector is most challenging in the near term. With peak electricity demand in 2030 expected to reach anywhere between 8 – 9 GW by 2030, integration of 1 GW of solar PV would contribute only a small portion of the overall system demand. Import of zero-carbon renewable electricity from Singapore's ASEAN neighbors is another option.

Discussion on some key areas

Evaluation of policies, target and measures

Singapore climate policies and targets are strongly based on national circumstances; Copenhagen/Cancun pledges: Singapore is on track to achieving its pledge.

Singapore's NDC? 36% reduction in EI by 2030 based on 2005 levels, based on economic modelling.

Climate Action Tracker: INDC as not sufficient/adequate, how to be more ambitious given our small densely populated AED?

Unlike the EU/California for example energy use and emissions submitted by installations to government agencies under our ECA and the enhanced ECA are not published for example in contrast to the emissions of refineries and petchems in California and the EU.

Carbon tax (installation emissions > 25 kt CO₂) will allow government to monitor efficiency improvement.

Cost-benefits of the incentive schemes of building energy programmes

Building (>2000 m² floor area) energy efficiency is under Building Control Regulation (2008). Minimum performance standards (eg ETTV Cooling Efficiency) and are mandatory.

Not certain if cost/benefit assessment is done, but scheme is successful in achieving its targets. Most unlikely to be phased out.

Factors impeding the take up of several of the schemes by the private sector. Some of these incentives are quite generous, but do not seem to be accompanied by more than a third of the enterprises taking them up.

Currently, industry energy efficiency (0.4 – 0.7 %) has not achieved its intended target of 1-2 % per year (Minister for the Environment and Water Resources, April 2017).

More urgent priorities, energy cost not a high % of overall, carbon tax of \$10-\$20 (2019) would nudge industries in this direction.

Conclusion

Due to its small land size, dense population, lack of alternative energy resources and being totally dependent on fossil fuel imports, energy efficiency is the key strategy for Singapore to reduce its GHG emissions. Early action taken to switch to natural gas makes GHG mitigation even more challenging.

While reducing emissions in the power generation sector remains a challenge in the near term, emission reductions in other sectors of the economy, including the industry-related sector have been identified. In the words of Foreign Minister Vivian Balakrishnan:

Singapore's 2030 pledge is unconditional and *"... is one that we believe is not only achievable, but also good for us"*

Thank You!

