11.00-11.15 Thailand Time (GMT +7)

UNITED NATIONS ESCAP
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Innovations and technology applications for clean and renewable energy transition in cities

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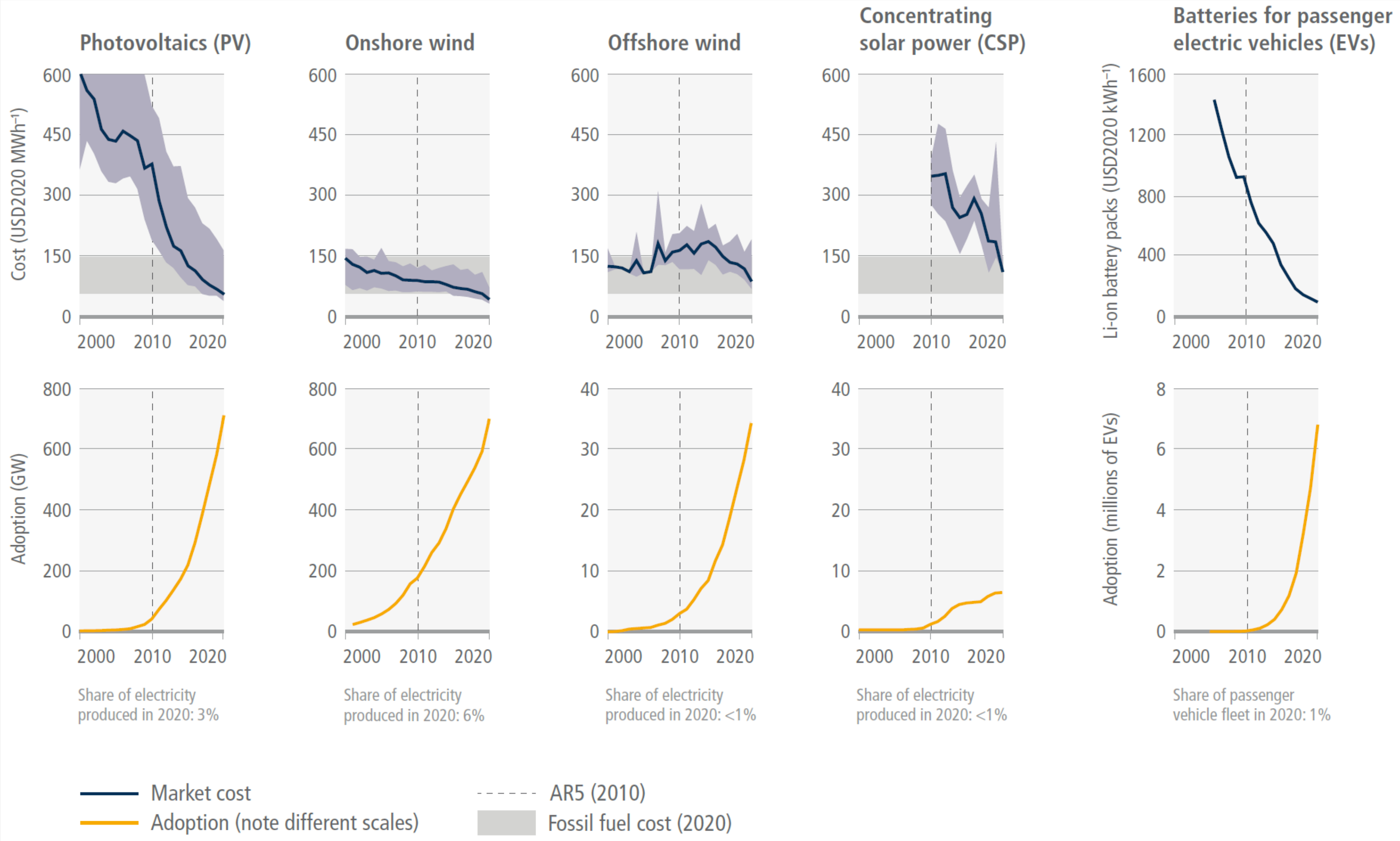
Urban energy system is dealt in piece-meal basis rather than a ‘system’

- Urban energy system is dominated by ‘centralized and supply-centric’ approach → seen as just an extension of national energy system without due recognition of energy resources and their potentials in cities
- There is an utter lack of ‘systemic approach’ and ‘comprehensive roadmaps’ in cities for enabling the evolving technologies and opportunities for ‘complementing’ towards clean and RE based urban energy transition
- Cities, by definition, have high population densities and compact urban fabric → RE is ‘not enough’ to feed a city’s energy demand, given limited city areas → cities’ must work with its hinterlands
- Several promising supply-side (PV, solar thermal, waste to energy, biofuels, waste heat) and a large number of demand-side technologies exist
- City’s renewable energy targets and climate mitigation commitments have yet not been able to rally ‘energy system integration’ in cities

Multiple low-carbon technologies have shown rapid progress in cost, performance, and adoption – enhancing the feasibility of rapid energy transitions



2010–2019

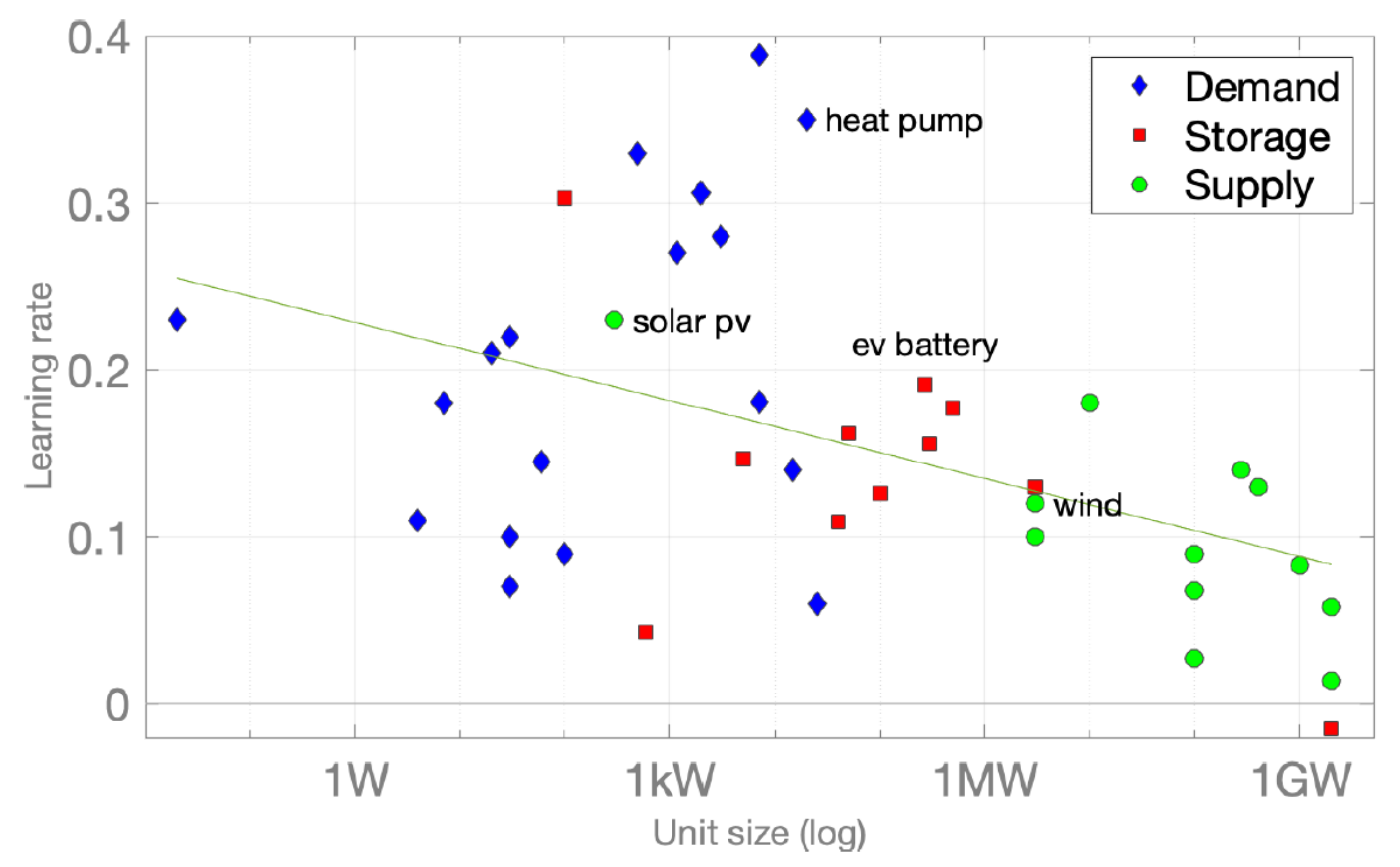
Sustained decreases in the unit costs of

- solar energy (85%)
- wind energy (55%)
- lithium-ion batteries (85%)

Large increases in their deployment

- >10x for solar
- >100x for EVs

Small 'granular' technologies not only learn but are becoming adopted faster than large technologies



Learning rates for 41 energy demand, supply, and storage technologies. Source: Sweerts et al. (2020)

Key technologies for clean and renewable energy transition in cities → Wide possibilities but no one-size-fits-all solution for cities

- Rooftop grid-integrated solar PV and smart grid **→front-runner**
- Solar thermal → have been use ‘quietly’; simple and proven technology
- Wind → Mostly in the research and development phase (R&D) for urban applications
- Bioenergy → limited use of modern bioenergy (such as bio-brickette); coupling of waste management with waste-to-energy incl landfill waste methane and incineration plants for electricity generation
- Geothermal energy → tapped through simple heat exchangers to heat or cool urban settlements in certain favorable locations
- Bio-gas → possible to tap the urban biodegradable waste into biogas that can be used as cooking fuel → urban industrial application (example: Poultry industry)
- Liquid bio-fuels → largely done at national scale while cities do have leverages

Key technologies for clean and renewable energy transition in cities → Wide possibilities but no one-size-fits-all solution for cities

- Technologies enabling injection of large-scale use of decentralized and variable renewable energy sources → smart grids, systems integration between energy-carriers, storage coupling, EVs
- Technologically, injection of the surplus power to the grid yet faces significant implementation hurdles
- Heating and cooling:
  - District energy systems coupled with renewable energy sources
  - Decentralized renewable energy options of heating applications such as → solar thermal on roof-tops, heat pumps, biomass, biogas, recovery of heat from wastewater, utilizing underground heat, amongst others

Rapidly expanding cities may have more opportunities

- Integrating urban planning to increase the energy efficiency of energy system at the scale of neighborhoods, such as district energy systems, reuse waste heat, micro-grids
- Enforcing or encouraging technology standard for buildings such as PV integrated buildings, use of heat pumps, connection to district energy systems etc
- Allow ‘well-planned space’ to maximize decentralized energy system from early on

100% Renewable Energy at City Hall of Yokohama City Japan

- City aims to replace all electricity consumed in city-owned facilities with RE by 2050
- Electric power used at the New Yokohama City Hall 100% renewable energy in 2020 -> reduce greenhouse gas emissions by about 5,800 tCO_2.

- Highest level of energy saving performance in building
- Electricity from waste incineration plant (self-consignment system)
- Electricity through retailer from Yokohama solar homes (Post-FIT)

https://www.city.yokohama.lg.jp/lang/overseas/climatechange/news/cityhallre100.html

Tokyu Railway to run from 100% renewable

- Tokyu Railway (in Tokyo) → 100 kilometers of railway tracks → serves 2.2 million people per day → connects Shibuya areas and Yohohama areas
- The train is driven by RE electricity including hydropower, geothermal-power, wind power and solar power.
- From 1st April, 2022
- RE procurement/Certificates

Photo Credit: https://en.wikipedia.org/wiki/Tokyu_Corporation

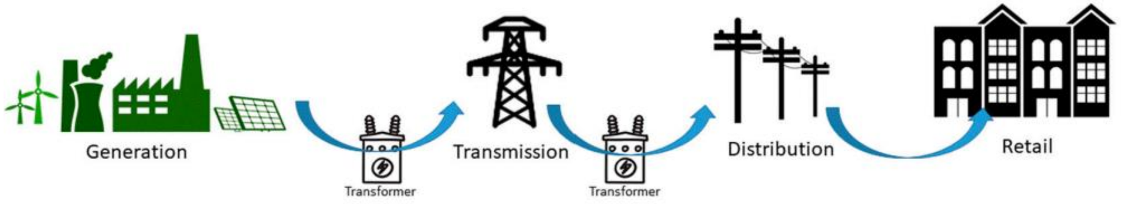
The Tokyo Metropolitan Government is enforcing a new system from April 2025 requiring home builders and developers to install solar panels on new buildings and houses. The system to cover about 50 major home building companies.

New houses and buildings with total floor space of less than 2,000 square meters are subject to this rule, excluding houses with roof space of less than 20 square meters.

Companies will not have to install solar panels on all buildings they build but are asked to meet a certain target, i.e. % of the share of their buildings with solar panels. TMG to set the target at 30% for an area including Chiyoda and Chuo wards, 70% for an area covering most of the rest of Tokyo’s 23 wards and the city of Musashino, and 85% for other areas.

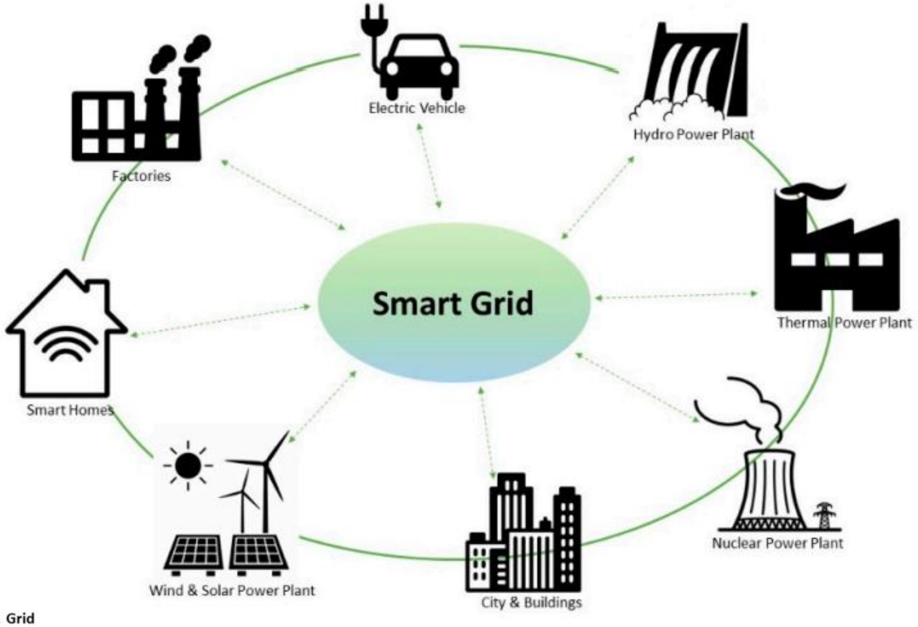
https://www.japantimes.co.jp/news/2022/09/09/national/tokyo-solar-panel-new-homes/

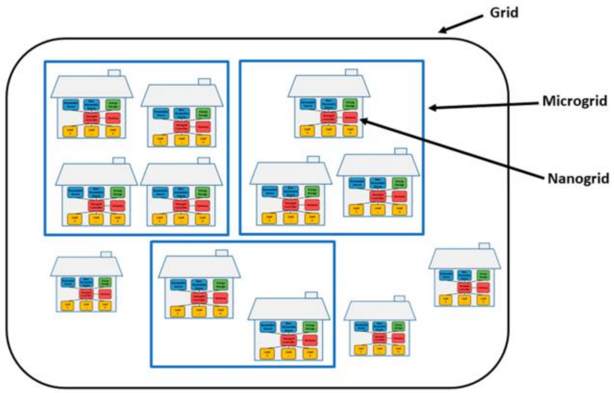
Traditional electricity systems *(linear, one directional, supply dominated, centralized)*



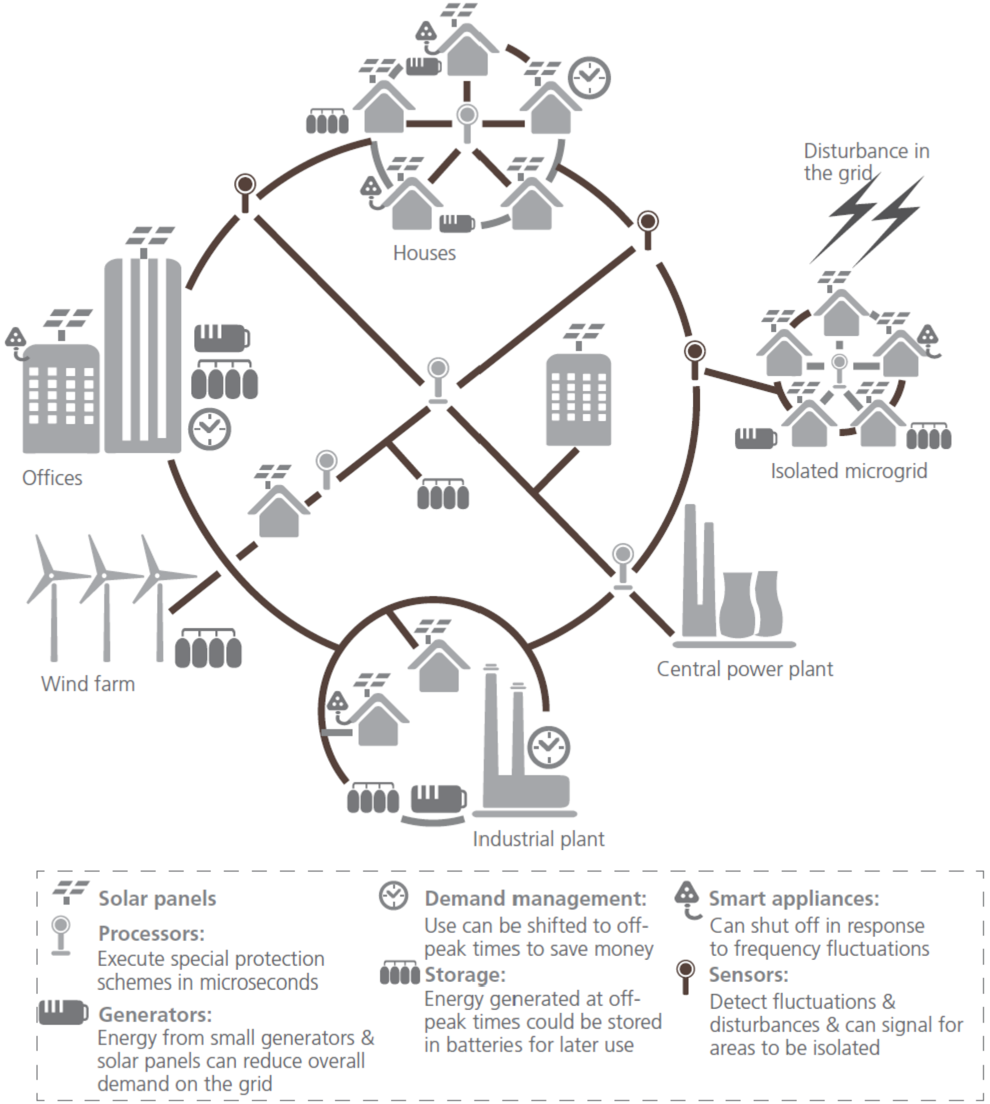
Sustainable Urban Energy: A Sourcebook for Asia
UNHABITAT (2026)

Smart future electricity system (multidirectional, decentralized, IT-enabled, IoT, demand response, prosumer)

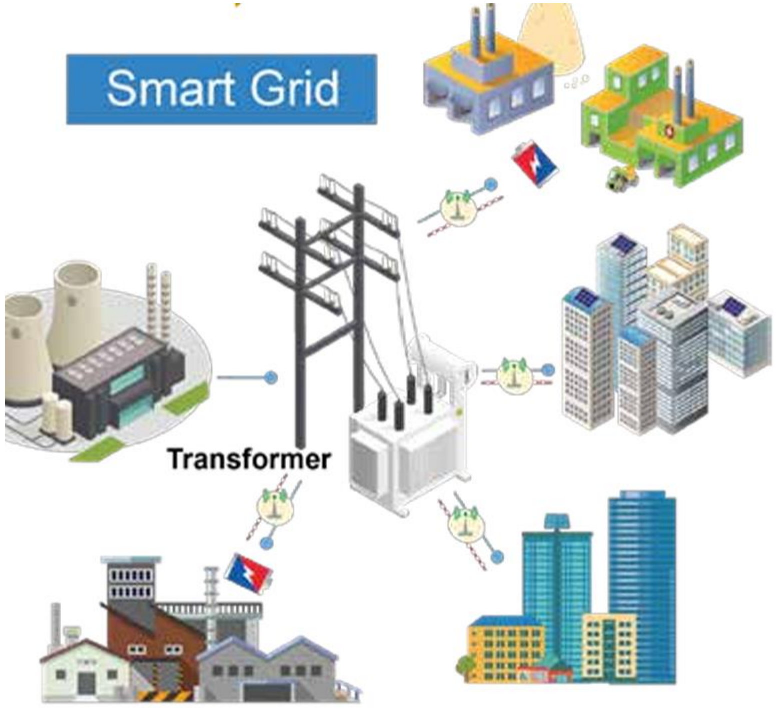


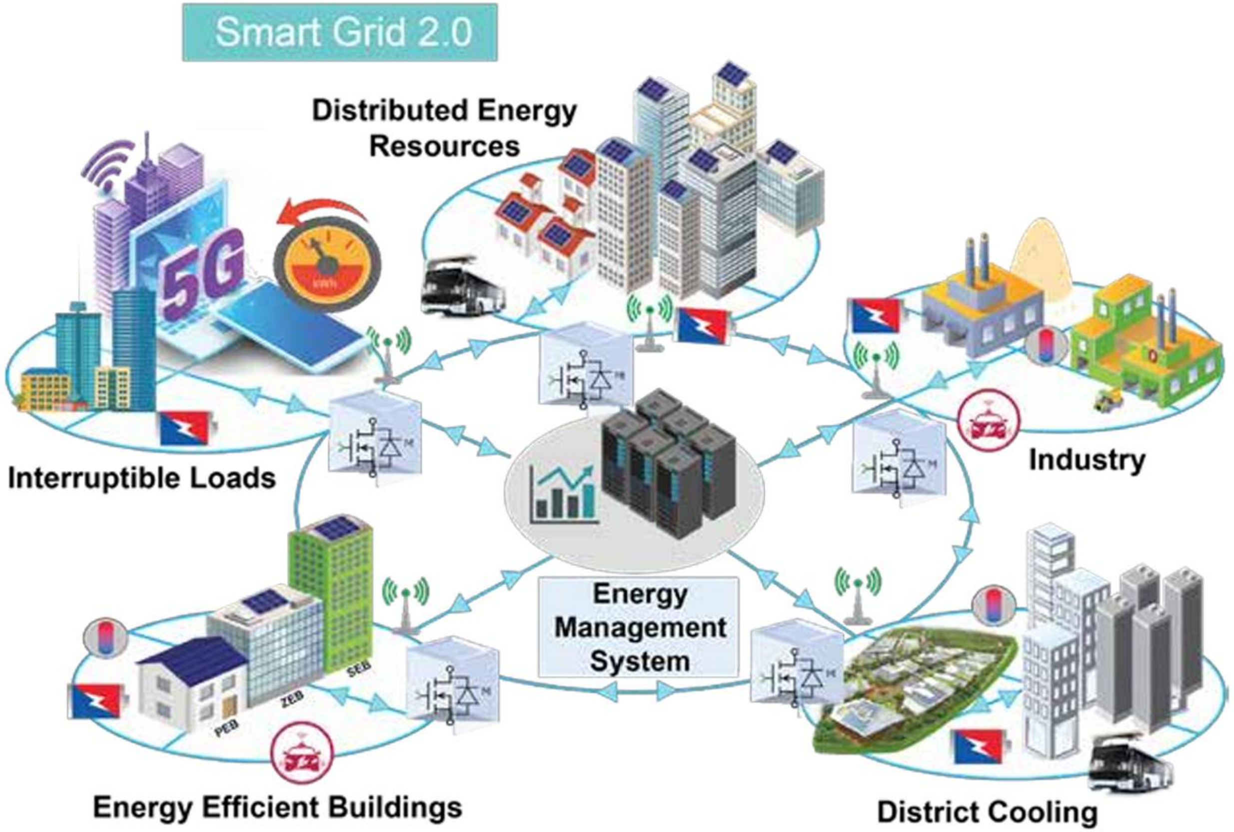


Farmanbar at al (2019)
Energies 2019, 12(23), 4484;
https://doi.org/10.3390/en12234484



Evolution in Smart Grid concept





Source: https://www.ntu.edu.sg/docs/librariesprovider60/publications/grid-2-0.pdf

Singapore Grid

- Most reliable and robust in the world
- Intelligent components in numerous segments of the generation and transmission network
- 3% network loss
- Partially smart
- More than 15,000 km lines
- Transmission & distribution system is underground to a large extent
- The Energy Market Authority (EMA) has introduced electrification of transportation, utility-scale energy storage systems(ESS), and open electricity market enabling customers to choose electricity retailer

The Singapore Grid Benchmarked Against Grids Worldwide

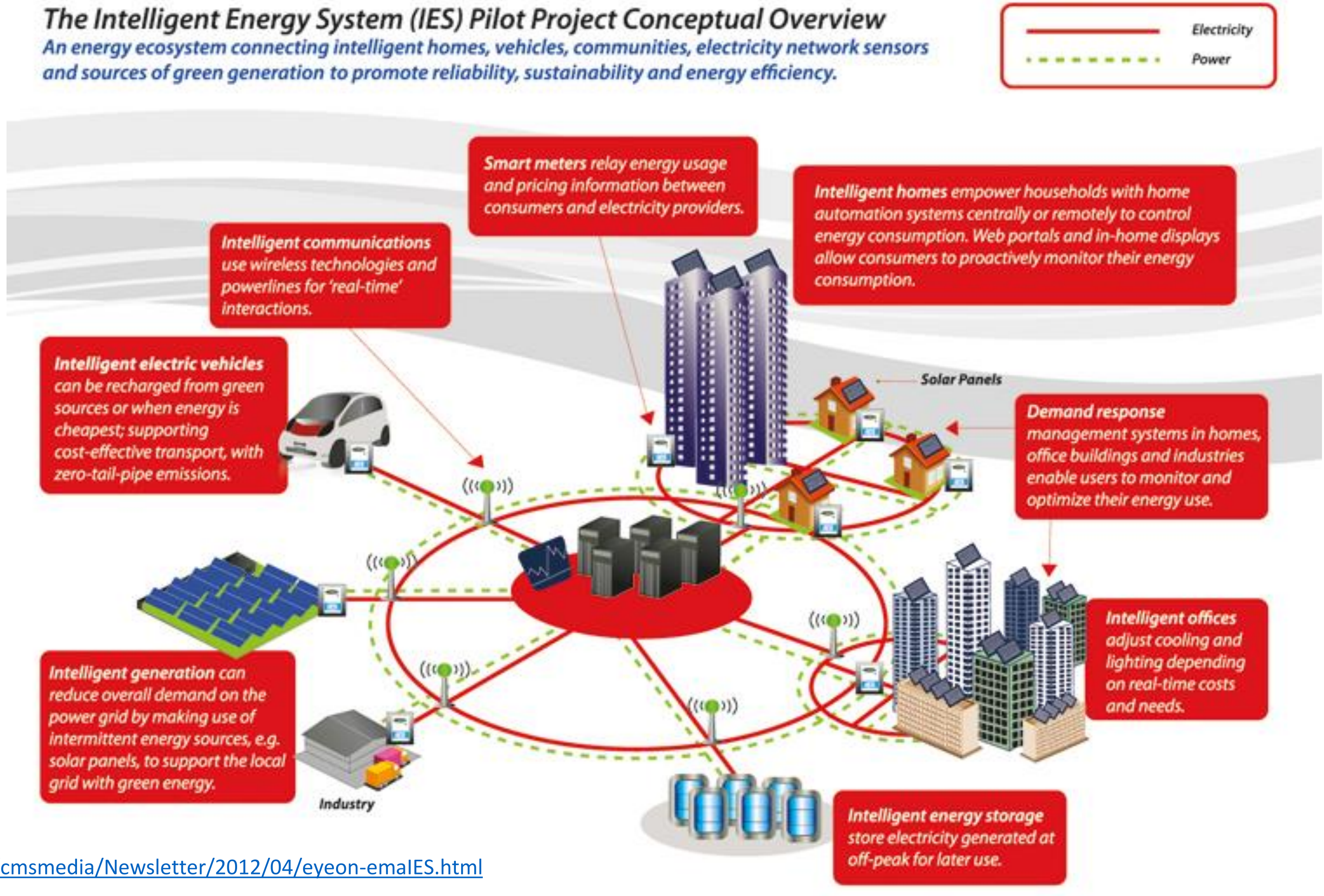
Benchmarking Results 2019

Rank	Country	Utility	Score (%)	Best Practices
1	**United States of America (USA)**	Pacific Gas & Electric Company (PG&E)	93	• Data Analytics • DER Integration • Green Energy • Security • Monitoring & Control
2	**United Kingdom (U.K.)**	United Kingdom Power Networks (UKPN)	89	• Monitoring & Control • Data Analytics • Green Energy • Security
3	**United States of America (USA)**	Southern California Edison (SCE)	88	• DER Integration • Data Analytics • Green Energy • Security
34	**Singapore (SG)**	SP Group (SP)	66	• Supply Reliability • Customer Empowerment & Satisfaction
52	**Thailand (THA)**	Metropolitan Energy Authority (MEA)	54	• N/A
57	**Malaysia (MY)**	Tenaga Nasional Berhad (TNB)	52	• Customer Empowerment & Satisfaction

Source: https://www.ntu.edu.sg/docs/librariesprovider60/publications/grid-2-0.pdf

Singapore's Intelligent Energy System (IES) Pilot

- Energy Market Authority (EMA) together with grid operator Singapore Power (SP)
- Consumers to access real-time info on electricity consumption enabling them to make decisions on their electricity usage
- Phase 1 from 2010→ development of the enabling infrastructure and the testing of smart meters
- Leverages on the Gov's Next Generation National Broadband Network and other com platforms
- Customers in various locations, including the Clean Tech Park at Jalan Bahar, participated in this Pilot
- Demand response → Participating consumers sign up with demand response aggregators and have their consumption reduced based on system conditions, such as reduce energy during periods of tight supply or when prices are high



https://www.ema.gov.sg/cmsmedia/Newsletter/2012/04/eyeon-emaIES.html

Singapore's "4 Switches" approach

1st Switch: Natural Gas is 95% of Singapore's electricity. Government to help generation companies improve the efficiency of power plants

2nd Switch: Solar – This remains Singapore's most promising renewable energy source. Solar target of 350 megawatt-peak (MWp) by 2020 is targeted. Working towards achieving a new solar target of at least 2 gigawatt-peak (GWp) by 2030, and an energy storage deployment target of 200 MW beyond 2025

3rd Switch: Regional Power Grids – Singapore will also explore ways to tap on regional power grids to access energy that is cost-competitive. This could be realized through bilateral cooperation or regional initiatives.

- 100 MW hydro electricity from Laos to Singapore operationalized from mid-2022 through Thailand and Malaysia (LTMS-PIP) from existing interconnections → first multilateral cross-border electricity trade involving four ASEAN countries

4th Switch: Emerging Low-Carbon Alternatives –including carbon capture, utilisation or storage technologies and hydrogen

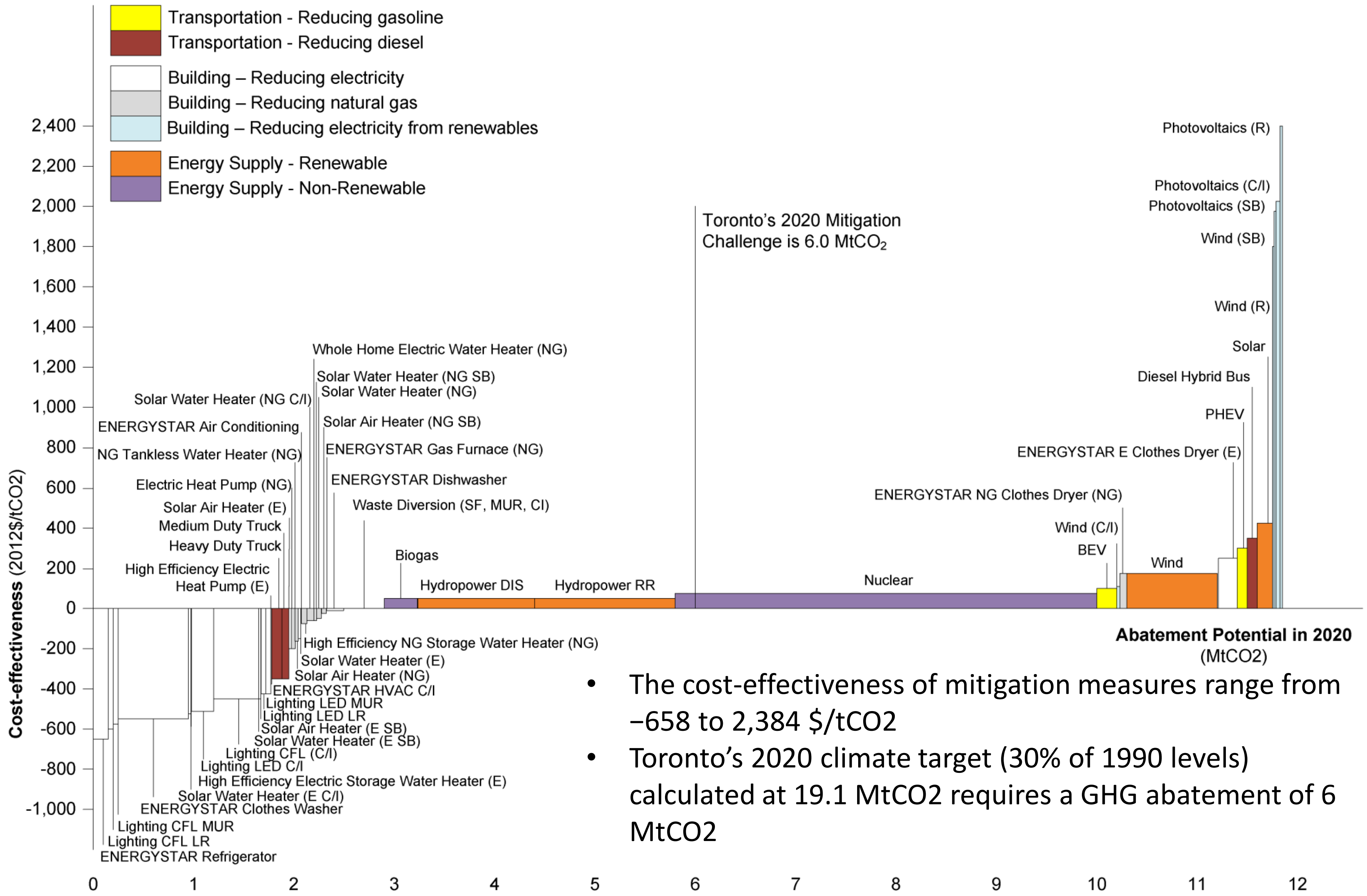
https://www.ema.gov.sg/media_release.aspx?news_sid=20191029Yk3uENU5Z4bL

Final remarks

- Rooftop grid-integrated solar PV is now evolving, and soon the fully decentralized storage-coupled RE in smart grid setting will evolve – it needs facilitation
- CHP in cold cities (Northern hemisphere) but limited application Asia yet → Solar thermal hot water systems are used in many cities → other REs have place-specific applications – needs to be scaled up
- As more smart-grids coupled with micro-grids emerges other technologies are coming into picture such as 'blockchain' as a tool to manage transactions in the smart grid → smart contracts, and the network acts as a transaction verifier → IoT and sensor applications, communication platforms and protocols, network security etc – strong groundwork needed
- There is an utter lack of 'systemic viewpoints' and 'comprehensive technology roadmaps' for cities for enabling the evolving technologies for complementing towards clean and RE based urban energy transition – role of this forum !!

Comprehensive technology assessment for cities is MUST

Toronto 2020 marginal abatement cost (MAC) curve showing mitigation measures by sector and a marginal abatement cost of 70 $/tCO2 for the city's 2020 target



- The cost-effectiveness of mitigation measures range from −658 to 2,384 $/tCO2
- Toronto's 2020 climate target (30% of 1990 levels) calculated at 19.1 MtCO2 requires a GHG abatement of 6 MtCO2

(R = Residential, LR = Low-rise, MUR = Multi-unit residential, SF = Single-family, SB = Small Business, C/I = Commercial/Institutional, NG = Natural gas, E = Electricity)

Ibrahim and Kennedy (2016)
Energies 2016, 9, 227; doi:10.3390/en9040227