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NATIONAL CLIMATE CHANGE SECRETARIAT
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SINGAPORE

ANNEX A

Highlights of Energy Technology Roadmaps

1. Background

- Singapore is seeking accelerate research, development, demonstration and deployment (RDD&D) of energy and low carbon technologies to address its energy and climate change challenges. Thus, the National Climate Change Secretariat (NCCS) and the National Research Foundation (NRF) have jointly commissioned a series of Technology Roadmaps.

- Each Roadmap highlights RDD&D pathways for technologies that can help increase energy efficiency, lower carbon emissions and increase energy security for Singapore up to 2030 and beyond. The Roadmaps also identify and prioritise technologies and actions required to accelerate these technologies into the market place.

- The development of each Roadmap was led by relevant Government agencies, in close consultation with other stakeholders within the Government, academia and industry. These roadmaps will guide the government agencies in formulating technology master plans and funding initiatives to secure Singapore's energy future and address climate change challenges.

- This is the second batch of energy technology roadmaps that NCCS and NRF have released. The first batch of roadmaps, covering Solar Photovoltaics, Carbon Capture and Storage / Utilisation, Green Data Centre and Building Energy Efficiency, was released on 30 Jul 2014

2. Electro-Mobility (E-Mobility) Tech Roadmap

- The e-mobility roadmap led by the Land Transport Authority (LTA) projects that as many as 30 to 50% of the vehicles in Singapore could have the potential to be EVs by 2050.

- Fleets such as Public Buses and Taxis offer the biggest potential for electrification. Although today, taxi and bus fleets account for only 3% and 2% of the overall vehicle population respectively, they hold the highest and second highest annual mileage per vehicle respectively. Buses also currently emit the highest amount of CO_2 per vehicle thus offering the highest carbon abatement potential. Both taxis and buses also have centralised pit stops (e.g. bus terminals), where charging facilities can be centralised for use.

- Potential for reducing greenhouse gas emissions
  - Replacing a conventional bus in Singapore with a battery electric version could lower emissions up to 56% per vehicle compared to current levels
  - Depending on the level of adoption, EVs powered by the grid (i.e. primarily energy generated by natural gas) can bring emissions down by 20% to 30% compared to Business-As-Usual scenario in 2050

- Research areas with most potential for Singapore can be categorized into 5 fields:
  - System integration research, such as research on holistic concepts for new cities which integrates electro-mobility
  - Singapore transport system research into electro-mobility and intelligent transport systems, and the interface between city and transport planning
  - Charging infrastructure technology (e.g. research on fast charging and stationary inductive charging) and placement of charging station in Singapore and their impact to the grid
  - Research on electrifying Singapore's fleets such as taxis and buses, and
  - Energy storage solutions for EVs through new battery materials and continual research into lithium-ion batteries.

3. Industry Energy Efficiency Tech Roadmap

- The Industry Energy Efficiency Tech Roadmap led by the National Environment Agency (NEA) and the Economic Development Board (EDB) identified 30 emerging and next generation technologies and 167 best available technologies and practices and estimated their potential for reducing industrial energy use and CO_2 emissions.

- Best available technologies are estimated to have technical potential energy savings of 13.1%. In addition, the 30 emerging and next generation technologies are estimated to have technical potential energy savings of 5.7% in 2030.

- The table below shows selected emerging technologies and the associated potential reducing energy use in 2030 in energy intensive subsectors.

Subsector	**Technology Name**	**Technical potential for reduction of subsector energy use (%)**
Refining and Chemicals	Improved Catalysts	2.9%
Refining and Chemicals	Refinery and Chemical Plant Integration	1.4%

Semi-conductor	Advanced Product and Process Control	4.9%
Semi-conductor	Ultra-pure Water Generation Technology (Reverse Osmosis with Electro-Deionisation)	4.6%
Generic (All)	Advanced Process Heater	0.2%

4. Solid Waste Management Tech Roadmap

- The Solid Waste Management Roadmap, led by the NEA, aims to establish possible pathways to achieve NEA's 2030 Waste Management Vision, which includes the minimisation of land footprint and the environmental impact of waste management activities, the maximisation of productivity while maintaining a high standard of public health, the maximisation of energy recovery from waste, as well as achieving the targeted national recycling rate of 70% by 2030, as outlined in the Sustainable Singapore Blueprint 2015.

- In order to achieve these goals, emerging technologies will have to be identified, developed and adopted in four main areas of waste treatment, namely (1) waste collection, (2) sorting and separation, (3) upcycling and (4) treatment.

- Technologies with the most potential for deployment in Singapore have been identified through the roadmapping exercise, and assessed on their feasibility and suitability for application in Singapore.

- Some key areas identified for further study and exploration are:
  - **Pneumatic Waste Conveyance Systems (PWCS)** for high-rise buildings, to achieve higher manpower productivity and mitigate environmental and hygiene issues associated with open collection methods.
  - **Demand-based waste collection** for higher manpower productivity and to optimise collection routes.
  - **Robotic solutions for waste collection** for higher manpower productivity.
  - **Advanced Materials Recovery Facilities (MRF)** incorporating auto-sorting technologies to effectively sort / separate dry recyclables.
  - A **Mechanical Biological Treatment (MBT) plant** to process municipal solid waste (MSW) to maximise recycling and energy recovery.
  - **Anaerobic co-digestion of food waste and wastewater sludge** to recover energy.
  - **Next generation Waste-to-Energy (WTE) plants** to enhance energy recovery efficiency.