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The role of municipalities in the renovation wave for improving the energy performance of buildings

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Executive Summary

For cities to meet the challenge of reaching carbon neutral by 2050, one option is to promote a renovation wave for buildings. A literature review of the initiatives, standards and regulations for energy savings and the renewable energy deployment in buildings in the EU, US and Asia shows the complexity of the effort, and the need to integrate multiple policies. A single policy simply cannot achieve the net-zero building levels needed to limit global warming to 1.5 degrees Celsius from pre-industrial levels. It requires the efforts of multiple levels of governments and the collaboration of a diverse variety of stakeholders to adopt stringent building standards. Examples in the municipalities of the EU, US Japan and Malaysia show that retrofits of public buildings serve as experimental grounds to draft such standards, and are seen as demonstration models to guide private building owners with regard to the feasibility and benefits of combining energy efficiency with the deployment of renewables.

Regardless of such initiatives, informational and financial barriers continue to be the main reasons that affect the motivation of building/homeowners' energy efficiency decisions, preventing them from choosing meaningful retrofits. The lack of detailed billing data for actual energy consumption levels of buildings/homes is another barrier for renovation as it reduces the means to analyse and develop effective strategies based on evidence. The use of smart technology, which is expected to introduce a new dimension of renovation by interconnecting buildings and increasing the energy performance at a district level, will require a new generation of urban planners.

The best practices and lessons learnt from the EU's intense experience in promoting renovation of its buildings over the last 50 years will be meaningful for Japan and the ASEAN region.

1. Introduction

Why are countries promoting nearly zero-energy buildings? Climate change is causing hazards all over the world in the form of droughts, heat waves, intense rainfalls, floods and landslide disasters. The Paris Agreement concluded at COP21 in 2015 set the target to reduce human-caused GHG emissions to "net zero" within the latter half of this century. The IPCC's Special Report on Global Warming of 1.5 °C published in 2018 finds that to limit global warming to 1.5 degrees Celsius from pre-industrial levels, CO_2 emissions would need to fall and reach "net zero" by around 2050. For cities to meet the challenge of reaching carbon neutrality by 2050, one option is to promote a renovation wave for improving the energy performance of buildings. Buildings are said to account for a significant proportion of GHG emissions.

A renovation wave is an initiative to make buildings energy-efficient, and less carbon-intensive. It can also contribute to air pollution, reduce energy expenditure, create local jobs and increase energy security (M. Economidou et al, 2020; T. Fawcett et al 2019; G. Mutani et al, 2018). Combining energy efficiency with the deployment of renewables, nearly zero-energy buildings (ZEB) play a key role in reducing greenhouse gas emissions and the linked global temperature increase.

EU sees a renovation wave for buildings as a main pillar of its Green Deal. For a post Covid-19 era, new policy instruments are being introduced to help buildings decarbonize, integrate renewables, promote resource efficiency and circularity. All new buildings in the EU are to be Nearly ZEBs from 2021 onwards (European Commission, 2021). Meanwhile, the US in 2007 specified a net-zero energy target of 50% of US commercial buildings by 2040 and a net-zero standard for 100% of new and existing commercial buildings by 2050 (Crawley et al, 2009). Japan's Prime Minister has declared that Japan would realise carbon-neutrality by 2050, and a roadmap announced in June 2021 addresses building energy efficiency as a crucial component (Ministry of Land Transport Infrastructure and Tourism, 2021). In Japan, electricity oriented CO_2 emissions from the residential and commercial sectors are to be zero by 2030. ASEAN member states share the common challenge of meeting rising demand for resources, and energy efficiency can play a key role in enabling a sustainable and clean energy future.

This paper aims to explore regulations and incentive mechanisms that will allow nearly zero-energy buildings or zero energy buildings to be built. As such, we identify innovative policies by different levels of government (i.e. national, subnational and local) that can be integrated to reach their shared goal. The remainder of the paper is divided into five sections. The next section underlines the need for an integrated approach for realizing carbon emission reduction in buildings. The third section reviews case studies in Asia. The fourth and fifth section reviews case studies of the EU and U.S. respectively. The final section reflects the important role played by municipalities and the issues they are facing.

2. The need for integrated building solutions

Energy efficiency first emerged in the energy policy agenda for the EU, US and Japan in the 1970s as a response to the oil crises in 1973 and 1979. It has since progressively transformed as carbon emissions were recognised as the cause for climate change and became part of the global agenda in 1990.

The early policies at the time of the oil crises were designed to stimulate energy security by reducing the rate of energy consumption growth. The early EU energy efficiency policies in buildings contributed to lower energy use of heating, cooling and ventilation appliances by introducing the concept of minimum energy efficiency standards. A common system for technical specification was developed between EU member countries that were until then very diverse (Economidou et al., 2020). Under its Energy Policy and Conservation Act, the US also developed its own minimum energy efficiency standards for appliances and equipment nationwide (Department of Energy 2021). Japan followed a path slightly different from the EU and US. The country's Top Runner Program finds the most efficient model on the market and then designates the efficiency of this model to become the standard by a specified time. Each manufacturer must ensure that the weighted average of the efficiency of all its products in that particular category is better than the top runner model by the designated year (Kimura, 2010). In each example, the energy performance levels were examined periodically to ensure that low efficiency appliances were eliminated from the market.

Following on from appliances, thermal insulation of buildings became the next target for

improvement. Insulation requirements were drawn up in the building efficiency standards of EU member states. The debate on climate change had become a global phenomenon by the 1990s and there were speculations on how much energy could be saved from both thermal insulation and efficient appliances. In addition, energy and climate targets were defined, and roadmaps for moving into a low-carbon economy were drafted. EU member states set about defining the minimum energy performance standards in new buildings and existing buildings under major renovation. These standards were then integrated into building codes, and updated to conform to their respective climate targets and roadmaps. In the case of Japan, it became mandatory for owners of large buildings to improve energy efficiency levels by one percent per annum.

This led to the energy performance of a building being benchmarked, which is typically done in either the amount used or by calculated energy use. Energy performance certificates (EPC) in the EU rank a building in terms of energy efficiency between A to G (with A being the most efficient) and are required for any real estate transaction. The building owner is obliged to make an EPC available for potential tenants or buyers (Economidou et al, 2021). The US does not have a mandatory benchmarking system but voluntary programmes such as the Environment Protection Agency's Energy Star Portfolio Manager for commercial and public buildings and the Leadership in Energy and Environmental Design (LEEDS) programme are well known. In Japan, owners of large buildings are obligated, under the national law, to submit a report on energy conservation measures prior to new construction, and major renovations (IBEC, 2021). In addition, some Japanese municipalities have introduced local benchmarking programmes that cover such buildings as well as those exempt from the national legislation. There are also multiple voluntary benchmarking programmes to stimulate building energy efficiency.

A market-based incentive mechanism was introduced in the EU and US in an attempt to change the behaviour of energy suppliers and energy end-users. In the EU, energy efficiency obligation schemes (EEOSs) are applied in several countries. These schemes consist of energy-saving obligations for energy distributors and/or retail energy sales companies and are in some cases coupled with a trading system. A tradable white certificate is one example that energy suppliers trade the energy savings gained from assisting their customers to take energy efficiency measures (EU commission, 2021). In the US the equivalent to EU's EEOSs is the energy efficiency resource standard under which utilities must procure a percentage of their future electricity and natural gas needs using energy savings achieved through customer, end-use efficiency programmes (ACEEE, 2021).

Regardless of the variety of national policies, energy renovation has not reached its optimum level. Informational and financial barriers are the main reasons that affect the motivation of building/homeowners to make decisions on energy efficiency, thus preventing them from choosing meaningful retrofits. Building/homeowners show interest in renovating as a way to save energy and money but decide against it, because of the complexity of a task that involves engineering, financial and legal expertise (Bertoldi et al, 2021). A broad range of business models for energy advisory services has been introduced as a solution, one of them being the energy service companies (ESCOs). ESCOs have been introduced worldwide offering energy performance contracts in which the energy savings delivered by the ESCOs are used to repay for retrofits. They are typically seen as useful for commercial buildings and large residential buildings. One-stop-shops (OSS) which are gaining momentum in the EU, offer customised

package solutions for small-scale home renovations as well as suggestions for financial solutions that suit the project at hand on a fee basis (Bertoldi et al, 2021). London and Nantes are examples of municipalities that are positively connecting local districts to OSSs.

Another common obstacle to the use of energy-saving technologies is their high up-front price. Demonstration projects are always a good policy avenue that municipalities can choose to facilitate innovation when the technology is still new and the market is not mature. In fact, this is one reason for the EU's yearly public sector target of 3% of central government floor area renovation (Economidou et al, 2000). Tax incentives are another policy, offered by forward-thinking municipalities to encourage certain types of purchasing. Some municipalities relax the floor-area-ratio when energy efficient appliances or renewable power generators are installed allowing the building owner to obtain revenue from more tenants (Tokyo Metropolitan Gov, 2021).

Buildings have become a complex integration of numerous technologies related to the building envelope and appliances, which are nowadays coupled with renewable power generation and ICT. The sophistication of the technology requires strong engineering, administering, financing expertise, whether it is a decision on a new construction or a major retrofit. These must also be complemented with good building maintenance and operation that follow afterwards. For this level of complexity, there needs to be integration of different kinds of policy instruments as it would be impossible for one policy to achieve optimum energy savings to enable zero or nearly zero-energy buildings on a global scale.

3. Zero Energy Buildings in Asia

a. Japan

Why is Japan promoting zero-energy buildings? One reason is that final energy consumption has tripled in the commercial sector and doubled in the residential sector since the oil crisis in the 1970s (Agency for Natural Resources and Energy, 2020). In addition, the importance of energy conservation in these sectors has been reaffirmed due to the tight supply and demand of electricity and unstable energy prices after the Great East Japan Earthquake (Ministry of Economy, Trade and Industry, 2021).

In Japan's Basic Energy Plan of 2014, the policy goal was to achieve net zero energy buildings for new public buildings by 2020 and in all new buildings by 2030 on average. Net zero energy buildings or ZEB are defined as buildings that have achieved an energy saving rate of 100% by increasing energy efficiency and power generated from renewables. In order to realise this policy target, the Ministry of Economy, Trade and Industry (METI) published the "ZEB Roadmap Summary" in December 2015, which summarises the definition and evaluation methods of ZEB, the feasibility of ZEB, and the measures to promote ZEB. In order to verify the feasibility of ZEB, case studies were conducted on the design (envelope and equipment) specifications and initial investment costs to achieve ZEB Ready (energy saving rate of 50%) for three applications: offices, schools and hotels. As a result, it was found that ZEB Ready is technically feasible for all three applications by using appropriate combinations of building materials and equipment available

on the market (Ministry of Economy, Trade and Industry, 2021).

METI has continued the phased improvement of the national Top Runner Program for building appliances to promote ZEB and Nearly ZEB (75% in energy savings using energy efficiency and energy production from renewables). Seeing the need to offer business support, grants were offered for both public and private buildings, and certified consultants named "ZEB Planners" and ZEB Design Guidelines were subsequently introduced (Ministry of Economy, Trade and Industry, 2021).

The rise in the number of ZEB and Nearly ZEB buildings has not been as high as hoped, mainly due to the information and financial barriers preventing ZEB retrofits and constructions. The leadership role of municipalities is crucial to overcome such barriers.

The general perception for ZEB was that it was only possible for new constructions. The municipality of Kurume, however, challenged this and set a high standard for other building owners, with its success in retrofitting an existing city hall building as a ZEB using the guidance of a certified ZEB planner and thermal insulation and building appliances sold on the market (Kurume City, 2021).

The Tokyo Metropolitan Government is one of the pioneers for benchmarking and energy efficiency credit trading mechanisms for buildings, and has attempted to spread ZEB awareness through its Green Building Program by mandating reports on large new building constructions that include ZEB ratings. It is also required for the building owners and the builders to hold discussion on installing solar PVs (Tokyo Metropolitan Government, 2021). For objectives similar to Tokyo, Kyoto Prefecture and Kyoto City have promulgated an ordinance requiring architects to explain the expected reduction in environmental impact from installing equipment into buildings / homes using renewable energy (Kyoto City, 2021).

Tottori Prefecture has established its own energy-saving standards (Tottori Healthy Energy-Saving Housing Performance Standards) for new detached houses. The standard sets three grades for heat insulation and airtightness performance that go beyond the national insulation performance defined for zero energy houses (ZEH). Grants are provided for new construction that comply with the standards (Tottori Prefecture, 2021).

b. Malaysia

Green technology, especially for buildings, is hoped to be one of the major engines for green growth and sustainable development in Malaysia. As such, multiple green building rating systems have been introduced to evaluate and benchmark environmental quality in buildings.

Due to the hot climate, a large portion of the energy consumed in buildings is for air-conditioning and ventilation appliances. Thermal insulation of the roofs and external walls, the use of external shadings would reduce the heat load of the buildings, and effectively increase the cooling capability of ventilation and air conditioning appliances. The Malaysian standard is named MS1525 and is a voluntary energy conservation guideline which incorporates minimum energy performance levels for building envelopes and building appliances, and promotes the

installation of renewables (Department of Standards Malaysia, 2017). Renewable power generation is being promoted with monetary incentives, and solar leasing programmes for vacant roof space (SEDA, 2021).

Unfortunately, there are as yet no regulators in Malaysia with the authority to regulate building energy use. Each of these measures runs independently and there are no penalties in place. The challenge is to integrate each measure into a single system. ZEB is hoped to be a concept that will be applied once the integration is in place. How it will be defined is being discussed in Malaysia with the support of Japanese government affiliated institution for energy conservation (SEDA, 2021).

In parallel with the national initiatives, metropolitan governments such as Kuala Lumpur and Johor Bahru are studying ways to promote less energy use in their cities. Kuala Lumpur, for example, aims to achieve carbon neutral by 2050, and has been retrofitting Kuala Lumpur city hall buildings and facilities with energy efficient appliances and solar photovoltaic (PV) systems to serve as a role model to other private building owners (Kuala Lumpur, 2021). Demonstration projects are always a good policy avenue that municipalities can choose to facilitate innovation when the technology is still novice and the market is not mature which is why the city announced plans to develop a future carbon neutral district near the city centre (UTM, 2021).

4. Nearly Zero Energy Buildings in the EU

The EU's Energy Performance of Buildings Directive asks Member States to establish minimum requirements for the energy performance of new constructs and existing buildings that need to be renovated so that by 2030, they will qualify as nearly zero-energy buildings (NZEB) for which the official EU definition is a "building that has a very high energy performance". Furthermore, under the Energy Efficiency Directive, all public bodies at all administration levels are subject to a renovation obligation which meets the NZEB standard (D'Agostino et al, 2021).

The concept of NZEB reflects the fact that renewable energy and energy efficiency solutions are both used. When renewable energy is generated on a building it will reduce net delivered energy. On-site renewable energy, however, in many cases is too small to account for all the energy demand. Therefore, an increased use of energy from off-site energy suppliers is also one option that is being explored (D'Agostino and Mazzarella, 2019).

EU Member States are required to include a numerical figure of primary energy use levels for the definition of NZEB, and this figure is to be included in each country's national plan for increasing the number of NZEBs. Some Member States link their NZEB level to one of the best energy performance classes in an energy performance certificate. This approach offers investors an idea of the building characteristics and has the potential to move the market towards NZEB (D'Agostino et al, 2021, Government of France, 2013, Government of Germany, 2013).

A variety of best practices that aim to transform existing building stocks can be found. Reading the national action plans for promoting NZEB drafted by France, Germany and Spain between 2013 to 2014, we see practices including technology awareness, incentive instruments, taxation mechanisms, energy-saving obligation schemes, or one-stop solution centres giving advice on

energy renovation(Government of France, 2013, Government of Germany, 2013, Government of Spain, 2014). Some policies are actually not limited to NZEBs but they are effectively lowering energy consumption levels.

For example, France has adopted several approaches, including a system of white certificates, which have become a key tool in French policy designed to reduce energy demand. White certificates are awarded by the Ministry of Ecological Transitions to eligible stakeholders that have undertaken energy-saving actions. The white certificates can be traded. Actions implemented are generally those that improve the thermal performance of building envelopes, and enhance the use of high-efficiency equipment (Bertoldi and Rezessy, 2009). The city of Paris, for example, has complemented this initiative by introducing an individual maximum level of energy consumption for buildings, and developing a platform of building renovation professionals who offer their energy services to observe such levels (Paris, 2021).

In the case of Germany, the Energy Efficiency Strategy for Buildings promotes the use of renewables for heating and cooling, accounting for two thirds of the energy consumption in Germany's buildings, and thereby increasing energy efficiency. Biomass boilers and heat pumps are seen as having a strong potential to cover a proportionate share of the heating and cooling requirements and are hoped to facilitate the transition from coal cogeneration district heating that has been the major method thus far (Federal Ministry for Economic Affairs and Energy, 2015). The city of Freiburg has mandated that all new construction uses only the latest cutting-edge energy efficiency designs. Most houses in the district of Vauban are now running on solar-powered energy (Freiburg, 2021). In 2021, Germany introduced a national fuel emissions trading system for sectors that are not covered by the European emissions trading system, thereby creating a basis for carbon pricing in those sectors. The national system covers the emissions produced by heat generation in the building sector (German Emissions Trading Authority, 2021).

Spain's long-term strategy for building renovation aims to boost energy efficiency in homes by energy efficiency improvement (thermal envelope); and energy efficiency improvement (renovation of thermal heating and DHW installations). The City of Donostia-San Sebastian has been successful in promulgating a municipal ordinance that required building owners with plans to retrofit to comply with a minimum energy performance levels in exchange for receiving

their building licenses (Donostia-San Sebastian, 2021). Between 2014 and 2019, Spain achieved the energy efficiency target in public buildings for EU Member States, whereby they must renovate 3% of the building floor area each year.

City	Policy
Nantes (France)	• Information hotline, "CoachCopro" web platforms, • One-stop digital shop for energy refurbishment of residential buildings
Paris (France)	• An obligation to carry out energy renovations for existing buildings with a surface area of 2,000m² or more • Introduce a maximum level of energy consumption for buildings • A platform of building renovation professionals • A regulatory consumption target of 50 kWhpe/m² floor area/year • All new buildings must incorporate a significant proportion of renewable or recovered energy into their supplies, corresponding to 60% of their energy needs between now and 2030 and 100% by 2050
Freiburg (Germany)	• Vauban is a city district in Freiburg in which the majority of homes run on solar energy generated on-site. • Freiburg mandate that all new construction uses only the latest cutting-edge energy efficiency designs- passivhaus standards. • Energy efficient retrofits are being applied to existing structures.
London (UK)	• A professional team assists local boroughs, housing associations and universities improve the energy use in homes of that specific district. (Retrofit Accelerator Homes) • A designated group of ESCOs assist local authorities, schools, universities, hospitals, leisure centres and museums, to implement retrofit projects and achieve large financial savings. (Retrofit Accelerator Workplace) • Energy company obligations for energy efficiency • The London Plan energy requirements for large developments • The London Green Fund.

Table 1: Policies of EU municipalities

5. Net-Zero Energy Buildings in the United States

Achieving zero energy in buildings has also attracted attention in the US. The Net-Zero Energy Commercial Building Initiative defined in the Energy Independence and Security Act of 2007 supports the goal of net-zero energy for all new constructions of commercial buildings by 2030. The act also determines a zero energy target by 2040 for 50% of both existing and new commercial buildings and net zero by 2050 (Crawley et al, 2009).

The ZEB definitions which have been proposed in the US differ according to boundaries and metrics (Torcellini et al, 2006):

•Net Zero Site Energy is a definition for generating more energy than it uses in a year, at a specific site.

•Net Zero Source Energy is a definition for generating more energy than it uses in a year, for a specific source.

•Net Zero Energy Costs is a definition that shows the amount of money a utility pays for the energy exported to the grid is more than the amount the building owner pays the utility for energy services over the year.

•Net Zero Energy Emissions is a definition used for a building that generates more emissions-

free renewable energy than it consumes energy from fossil fuel.

The federal government has introduced initiatives to support retrofits of residential buildings through a grant programme offered to households with low incomes. A variety of other retrofit programmes are also offered by states, municipalities, utilities and others (ACEEE, 2021).

For example, the State of California has a separate set of energy standards (Title 24) governing its residents, allowing them to pursue higher energy efficiency levels compared to other states. California residents are expected to abide by and comply with stricter Title 24 Standards which are above and beyond those outlined by the national government (California, 2021).

Furthermore, cities inside the state of California complement Title 24 by determining their own unique energy efficiency measures and facilitating the use of more renewable energy in buildings which take in their local characteristics. The City of Carlsbad has promulgated a water heating emissions reduction ordinance to promote solar thermal or heat pump water heaters in homes (Carlsbad, 2021). The City of Berkeley has decided to electrify all new buildings from 2020, and advance this to neighbourhood scale electrification (City of Berkeley, 2021).

Municipality	Policies
California	• 100% of new commercial buildings and 50% of existing buildings to be net zero by 2030. • California utilities and the Energy Trust of Oregon are implementing commercial new construction programs that provide additional incentives and design assistance for owners and design teams whose buildings approach NZEB efficiency levels (i.e., 40-50% more efficient than current code). • Passed several bills to increase energy efficiency requirements in new and existing buildings, increasing uptake of decarbonising technology in buildings, and increasing the use of renewable energy to further reduce greenhouse gas emissions and supporting a transition from fossil fuels. • A statewide energy benchmarking and disclosure program for large buildings • On-site solar requirements for new residential construction in the State of California
San Francisco	• San Francisco's Existing Buildings Ordinance requires large non-residential and multifamily residential buildings to do energy benchmarking and energy audits, • Renewable energy supply through CleanPowerSF
Los Angeles	• Sustainability Plan that includes ambitious emissions standards for new buildings to be zero-emission by 2030 and all existing buildings by 2050.
Carlsbad	• A water heating emissions reduction ordinance that will promote the installation of solar thermal or heat pump water heaters in homes.
Berkeley	• An ordinance to build new buildings all-electric starting in 2020. From 2022, the program will lead to phase II which would also include advancing neighborhood scale electrification. Voluntary electrification -> mandatory electrification through minimum performance standards and financing programs.
San Diego	• A zero emissions policy that applies to new municipal construction projects • Building Energy Benchmarking Ordinance in February 2019. The ordinance requires commercial buildings over 50,000 square feet and multifamily and mixed-use buildings greater than 50,000 square feet and with 17 or more residential accounts to submit energy data to the City • The local utility SDGE offers rebates for businesses that install energy efficient appliances in 2021. • It is also a member of the 2030 District program which aims to achieve a 50 percent reduction in energy, water and transportation emissions in participating buildings by 2030.

Table 2: Policies of U.S. municipalities

6. Lessons learned and the way forward

We have seen that buildings have become a complex integration of numerous technologies concerning building envelopes and appliances. This is a situation that requires a variety of policy

instruments to promote reductions in carbon emissions since one policy cannot be accountable for achieving an optimum level of energy savings. It is also apparent that actions are required from different levels of government including local, regional, state, national or federal.

Municipalities have shown that they are often the drivers for actions and policies to promote the renovation wave. Examples of forward-looking municipalities in the EU, US. and Japan indicate that they are finding ways to complement national initiatives.

Some municipalities stipulate their own individual energy performance standards in their ordinance and/or building codes to drive building owners to build ZEBs. The experience of California shows that rather than promoting this on their own, policy integration between the state and the cities enhances the motivation and capacity to develop standards that go beyond those outlined by the national government.

Informational and financial barriers are the main reasons that affect the motivation of building/homeowners' energy efficiency decisions, thus preventing them from choosing meaningful retrofits. Some municipalities, such as London and Paris, have decided to rely on external advisory teams to help local districts, or set up informational online platforms that offer technical and financial guidance as in the case of Nantes. The metropolitan government of Tokyo has a team of in-house professionals that analyse and provide detailed guidance for buildings to pursue better energy performance.

The lack of detailed billing data for actual energy consumption levels of buildings/homes is another barrier for renovation as it reduces the means to analyse and develop effective strategies based on evidence. The EU's mandatory use of energy performance certificates is an example that may warrant revisiting by Japan and ASEAN where voluntary programmes are being used. Tokyo Metropolitan Government and Kyoto City have introduced their own programmes that led to the collection of building data and subsequently allowed for guidance based on data.

The use of smart technology, which is expected to introduce a new dimension of renovation by interconnecting buildings and increasing the energy performance at a district level, will require a new generation of urban planners. Demonstration projects at the municipal level will be informative in identifying the challenges and solutions for such new technologies and educating new talents and skills that is needed for full-scale implementation.

The best practices and lessons learnt from the EU's intense experience in promoting renovation in its buildings over the last 50 years will be meaningful for Japan and the rest of Asia. Programmes that encourage sharing of such knowledge through city-to-city partnerships is one avenue that is gaining momentum with increasing impacts as cities start to commit to reducing CO_2 emissions to "net zero" by around 2050.

This discussion paper is limited in that most of the analysis is based on literature reviews. For the next step, the authors intend to conduct a series of interviews with municipalities that should allow further in-depth analysis on the pending issues stated above.

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