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ENVIRONMENTAL INNOVATION: OPPORTUNITIES AND CHALLENGES IN HONG KONG

TECHNICAL REPORT

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Executive Summary

Increasing global sustainability challenges call for a radical improvement of resource efficiency, environmental quality and development styles. Under such momentum, the environmental innovation will become a new pillar of economic growth over the coming years. Regionally, China is now a world leader in green technology and services investments, and thereby constitutes one of the fast growing and important regional markets for Hong Kong on environmental innovation. However, positioning Hong Kong to fully seize such opportunity presents great challenges and requires joint actions, commitment and investments from all stakeholders.

By providing a platform of discussion and valuable sharing of experiences and expertise among various stakeholders including local and oversea professionals, experts, academics, research institutions, businesses and policy makers, the Annual Forum of the HKIE-Environmental Division aims at exploring potential future axes for boosting the breakthroughs of environmental innovation in Hong Kong in the current regional context of large market opportunities. The Forum noticed significant efforts invested by local stakeholders to stimulate the growth of environmental innovation market in Hong Kong for the development of the environmental industry. Digital revolution might be an important trigger of environmental innovation in Hong Kong. Nonetheless, the breakthroughs of the environmental innovation require adopting appropriate new strategies.

Short Term Strategy

-First, it is important to build on the environmental innovation success stories already in place. Local demand-pull strategy for green technologies, products and services may consist for the Government, of increasing public environmental awareness, by developing proactive political leadership in collaboration with all stakeholders for achieving existing environmental targets based on strategic planning and diverse promotional activities. The Government may reinforce its own green procurement policy to influence markets and manipulate market mechanism through levies and subsidies to being about more environmentally beneficial outcomes. This may help to provide a physical and information/knowledge-based infrastructure to boost further innovation, new research and development of initiatives with new partnerships between industry and academia. It is also important to reinforce funding supports to help small and middle firms to develop new set of environmental innovation products, technologies and services.

-Second, with the adhesion and commitment of all stakeholders, adoption of policy reforms for enhanced digitalization and green innovation regulations to stimulate the change of consumer taste, might create an opportunity for rapid growth of local environmental innovation market in various fields including green building, mobility, water, waste, air and energy generation and supply.

Long Term Strategy

-In a longer term, Hong Kong stakeholders must look towards building up environmental industry with flourishing innovation, creativity and technological advancement. Some of key directions that could serve as potential triggers of the development of local environmental market might be the development of “Smart City” model; green built environment; green services and the circular economy. However, the development of strategies for permanent environmental innovation appears to be crucial and requires joint actions from the Government and all other key players. This would direct the environmental innovation with appropriate policies to produce long term economically successful innovations. Price mechanisms (in particular taxes, subsidies and covenants) could be applied, similar to experiences in many other countries.

-Hong Kong stakeholders should also strengthen their collaboration with abroad advanced economies in new green technology and service development. New partnerships with educational institutions at all

levels, improved vocational training, professional development and increased support for research are the priorities.

In addition, research programmes could bring together firms that should potentially benefit from a technology in order to ensure exploration of a wide range of potential applications. On the other hand, the stakeholders should initiate or reinforce the coordination with international regulatory agencies responsible in guiding green innovation development in order to anticipate adequate levels, forms and standards of green technologies.

Specific Recommendations

Based on analysed challenges, perspectives and proposed future directions for the environmental innovation by the Forum participants, salient actions needed from Hong Kong stakeholders can be summarized as follows:

-Adopt an open-market approach through improving green procurement processes;

-Provide adequate policy support, strong market signals and, where appropriate and in strategic areas, subsidize environmental innovation for corporate growth and development;

-Establish an environmental information and technical support center;

-Support and encourage environmental innovation businesses to introduce advanced technology and services through the provision of tax deductions / reductions, and exemptions as well as any appropriate incentives, facilitation and support for technology piloting;

-Establish a Green Innovation Development Fund to support the research and development of circular economy, in particular, local technological innovation in research institutions and enterprises;

-Formulate market entry policies for resource and energy-intensive technology and equipment;

-Explore and establish an economic compensation system / mechanism for the environment innovation by using extra charges, resource taxes and fees collected from various charges;

-Encourage green manufacturing, services and operation on the most cost effective scale.

-Establish a long term circular economy fund (special Government bonds, revenue from issuing a circular economy lottery for the public, waste discharge fee, resource taxes, surcharge levied for purchasing of luxury cars, large electrical household appliances, funds from non-government sources and international sources). Stakeholders should formulate regulations and rules of fund allocation, use, management, and auditing;

-Emphasize on green products and services that are exportable;

-Recognize that the development of environmental innovation strongly lies in its capability to act as green solution provider to address local issues in accordance with established sound policies and rules;

-Closely collaborate with each other for capital cost control, knowledge sharing and to increase public awareness and local green innovation demand;

-Commit to promoting capacity building on environmental innovation oriented business in collaboration with Academia and international technological quality regulation bodies;

-Learn from oversea successful models of green innovation.

1-Introduction

The world is increasingly recognizing that environmental challenges such as climate change, drastic disasters, heavy pollution, unsustainable production practices, and resource scarcity have a significant impact on economies, human health and development. Moreover, keeping the global average temperature increase below 2°C (in accordance with the Paris Agreement, Conference of Parties 2015, COP 21) requires imperatively from all Parties a dramatic reallocation of investment away from heavy-pollution and carbon-intensive economy to multi-dimensional environmental innovation, low-carbon and climate-resilient strategies axed on the development of innovative and cost-effective green technologies, energy sustainability and adequate policies. Incontestably, there is a worldwide growing need to find innovative approaches that can help to address sustainability while offering opportunities for growth, competitiveness and prosperity.

China has therefore promptly primed industry greening and pledged dynamic environmental innovation, low carbon economy and pollution phasing-out with strategic plans over the coming years. As a key city with strong transformative change in the Pearl River Delta Region and fully integrated into sustainable alternatives for climate resilience within the Asia Pacific Economic Cooperation, Hong Kong has to play an important role within such national environmental innovation momentum and fully seize existing large regional opportunities to increase green consumption and diversify its economy. In this regard, there is an urgent imperative in Hong Kong to significantly scale-up actions on key levers of environmental innovation including effective pollution abatement, development of green investment, cost-effective green technologies, enhanced energy efficiency and social behavioural changes with further implications on Hong Kong's sustainable development.

It is therefore timely for the HKIE-Environmental Division to promote the discussion and experiences sharing among various stakeholders including professionals, experts, academics, research institutions, businesses and policy makers on the environmental innovation through the Annual Forum. The main objectives are to focus on an integrated multidisciplinary approach of the environmental innovation and exploring potential axes to contribute to significantly boost local environmental industry and phase-out pollution in line with the national momentum of green innovation. As such, the Forum provides the HKIE-Environmental Division with the opportunity to inspire, empower, and inform professional bodies, public and all stakeholders on emerging environmental innovative waves in terms of green technological development, green innovation and green strategic plans; and to mobilise practical knowledge and know-how for dealing with related cross-cutting and challenging issues.

This technical report summarizes discussed salient aspects including the concept of environmental innovation with implications of social behavioural changes and sustainable development, expertise and experiences in driving environmental innovation and related challenges, business opportunities and competitiveness of green innovation, and recommendations for overcoming multi-dimensional challenges and enhancing stakeholder's capacity for promoting green innovation.

2-Concept of Environmental Innovation

2.1 Definition

The Forum participants agreed that the concept of environmental innovation lies in a worldwide political environmental discourse extended beyond purely ecological to include real sustainability. In the current sustainability-constrained world characterized by resource scarcity, in-deep changes of the production, business processes, economic policies, lifestyles and social behaviour are the pillars of the sustainable future and wellbeing. Environmental Innovation consists of approach and creative ways aiming at addressing social, economic and environment needs in a holistic mode to drive change qualitative towards sustainability. Environmental innovation are therefore innovative solutions for environment challenges that incorporate sustainability across the value chains in all sectors, modifications and creative solutions applied to ecosystem services, products, processes, market approaches and organizational structures, policies and governance which lead to enhanced sustainability, productivity and eco-benefits (ecological and economic). Innovative solutions call for life-cycle thinking while incorporating all aspects of sustainability including economic, social and environmental and fostering social behavioural changes across all aspects [12].

Innovative solutions attract new investments and reinvestments because they have higher resilience and viability in the long-term making them profitable, since investments decisions are increasingly being made based on sustainability. Environmental innovation undoubtedly increases technical capacity through acquisition of skills, knowledge, exchange of information and participation from collaboration with the entire value chain partners. The innovation certainly opens new markets to cater to untapped new demand in market segments. Moreover, innovative solutions increase productivity and profitability by identifying opportunities for improvement through material, water and energy efficiency, minimizing wastes, responsible consumption and production and shared risks and gains across value chains, thereby creating wealth and jobs.

In short, the logic behind environmental innovation embodies a paradigm shift to incentivize all stakeholders to accelerate political and socioeconomic transformation. Environmental innovative, in this context, is neither invention nor restricted to green technology. Conventionally, inventions focuses mostly on technological developments, but innovative solutions are facilitated by non-technological changes as well [12].

2.2 Environmental Innovation for Equity and Integrative Management

As highlighted during the Forum, the concept of equity represents the social dimension of environmental innovation. In this sense, environmental innovation might be seen as a criterion for environmental justice. The concept of equity itself encompasses various concepts such as environmental, social and economic justice, social equity, equal rights for development, quality of life, equal economic distribution, freedom, democracy, public participation and empowerment. Innovation should be achieved through the effective balancing of social, environmental and economic objectives. The environmental innovation and sustainability emphasize the equity issue between generations. Basically, in view of equity, environmental innovation can be considered as a strategy of development that results in the enhancement of human quality of life and the simultaneous minimization of negative environmental impacts.

There are two types of equity according to sustainable development process: intergenerational and intra-generational. Intergenerational equity refers to the fairness in allocation of resources between current and future generations. This implies that the economic systems should be managed to live off the dividend of resources, maintaining and improving the asset base so that the generations that follow will be able to live equally well or better. In this regard, environmental innovation and sustainability are simply matters of distributional equity, about sharing the capacity for well-being between present people and future people. On the other hand, intra-generational equity refers to fairness in allocation of resources between competing interests at the present time. The integrative management represents the aspect of

environmental innovation that focuses on the holistic view of social development, quality life, economic growth and sustainability. Accordingly, the integration of environmental, social, and economic concerns in planning and management for environmental innovation is essential. From a policy perspective, the concept of integrative management draws attention to the importance of maintaining a safe minimum standard for all living and non-living assets necessary to maintain ecosystem functions and life support systems, along with at least representative forms of all other living natural assets [12].

The Forum identified four key areas of integrative management including integrating environmental innovation concerns and development at the policy, planning and management levels; providing an effective legal and regulatory framework; making effective use of economic instruments and market and other incentives; and establishing systems for integrated environmental innovation and economic accounting. Simultaneously actions are taken to address environmental, social and economic challenges through policy, financial and market instruments, partnerships, concertation and innovative solutions. As such, the integrative management consists of an adjustment or even a fundamental reshaping of decision-making in order to put the environmental innovation and sustainable development at the centre of socioeconomic and political decision-making [7].

2.3 Implications for Social Behavioural Changes

Beyond policies, rules, regulations, technological innovation, the environmental innovation requires significant changes in social behaviour and life styles. There is a broad societal desire to become more sustainable, less wasteful and more efficient, however there are barriers to this becoming a reality. Despite multidimensional environmental challenges associated with the pressing issues of climate change impacts , greenhouse gas emissions, heavy pollution, natural environmental degradation, and depletion of natural resources, many environmental issues, are perceived as ‘psychologically distant’, whereby the severity of the threat to local issues and the individual is perceived to be low.

A major challenge will be to create messages to reverse the psychological distance of environmental issues, while tailoring these messages for different audiences and avoiding extreme and frightful messages that will most likely have adverse impact. A first step to reversing psychological distance is to highlight a specific environmental issue and make the problem obvious; littering campaigns are an example of this, where awareness campaigns isolated the issue, successfully increased awareness and encouraged social behavioural changes. Basically, eight variables applicable for effective occurrence of social behavioural change have been highlighted during the Forum, including [7]:

- A strong positive intention or commitment to perform changes
- Drastic environmental constraints allow the behavioural changes to occur
- Skills/ability necessary to perform changes
- Understanding the attitude and anticipated outcomes of changes
- Social norms will influence the individual to perform changes
- Consistency of change perception with people self-image without violation of personal standards
- Positive emotional reaction to performing changes
- Self-efficacy to execute changes

Stimulating a deliberative engagement with incentive measures might be effective for building support and legitimacy for big, transformational changes in society. It involves deliberative engagement with people, with the objective of encouraging a shift towards intrinsic values. The approach allows an open and honest discussion of the scale of change needed, while avoiding the perceived patronising nature of some social marketing campaigns. This could involve working partnerships with community groups to target specific areas where environmental behaviour change would deliver tangible social and economic benefits. Successful engagement with visible benefits could provide a much-needed catalyst for wider change. Encouraging people to commit to specific measures increases the probability that they will act on their commitment [12].

Linking environmental behavioural change with other already familiar campaigns could prove effective. Providing a target for people to aspire to real and beneficial sustainability could provide one of the key motivators to encourage change. There is also a need to promote greater public understanding and education; people seem to be aware of the problems but are not making the necessary changes to tackle them. Further clarity and provision of a stage by stage relationship can only help to inform people of the relationships between behavioural changes and the impact they can have on the issues that they are already aware of.

2.4 Challenging Issues

The Forum participants agreed that sustaining and enhancing environmental innovation and social behavioural changes are challenging for the Government, NGOs, urban developers, businesses, investors and other stakeholders, particularly in Hong Kong. Some of the key challenges discussed during the Forum are highlighted below.

(1) Limited Capacity and Skills for Environmental Innovation

Increasing environmental innovation tends to suffer with many barriers, including inefficiencies in the communication process within corporations, lack of social education and corporate environmental training, managerial limitations to understanding the relevance of green issues, difficulties to build networks between partners and green innovation teams, unskilled research and development teams for green innovation, lack of partnerships between businesses and research institutions at local and international scale, low perception of green innovation gains, difficulties in obtaining financial resources for environmental innovation projects, and sluggish environmental regulatory system based on governmental inefficiencies and inconsistency of environmental regulatory changes. Hong Kong consumes various products from Mainland China and overseas with critical lack of recycled materials. Hong Kong therefore has an obligation to act responsibly, source and consume resources more sustainably. Related critical aspects are public information, strategic governmental plans for green innovation, mastery of new environmental technologies, continuous high-quality professional development, and research ability in advanced green technology development [7].

(2) Persistent Social Disparities

Locally, according to the 2016 Arcadis Sustainable Cities Index, Hong Kong is associated with strong disparities in wealth, education and knowledge on environmental innovation. Taking actions to ensure that all people enjoy at least a basic standard in the quality of life, with food, a dwelling, education and health and a sense of opportunity, is thus critical to bind a city's diverse population together for environmental innovation. Socially, Hong Kong has made significant gains in human development. However this development has been achieved at the expense of Hong Kong's ecological footprint. Greater equality in Hong Kong will drive a sense of inclusion in its citizen. . Hong Kong's current model of human development is far from sustainable when viewed from resource consumption and environmental burden perspective. In addition, the city has to find solutions to social infrastructure, work-life balance and housing issues affecting both its young and increasingly aging population. Concerted actions and commitment of the Government and key stakeholders should focus on the applicability and performance tracking system of effective social behavioural change approaches for environmental innovation [7; 9].

(3) Weak Demand of Environmentally Innovative Services and Green Products

Weak demand of environmentally innovative services and green products from local market due to low environmental awareness of customers, lack of information and promotional activities on recycled products, technologies and innovative solutions, significantly hinders the development of the environmental industry. Despite observed growing tendency for Government green procurement, the demand and consumption of green products are still critically weak. This also curbs the interest and motivation for environmental innovation. The Government and all stakeholders (businesses, diverse experts, Universities /R&D Institutions, NGOs, professional bodies, public, etc.) are recommended to

closely work on regulation and incentives of all flourishing lines in order to stimulate and sustain the demand of innovation, creativity and technological advancement [7].

3-Experiences in Driving Environmental Innovation in Public Projects

3.1 Experiences from Hong Kong Government

(1) Development of Blue-Green Drainage and Sewage Treatment Services in Hong Kong

The environmental experts of the Drainage Services Department (DSD) are proactively committed to providing world-class stormwater drainage and sewage treatment services to support the sustainable development of Hong Kong. DSD endeavours to take into account ecology and environment protection needs in planning, designing, constructing and maintaining drainage, flood control and sewage treatment facilities. In the field of water conservation and stormwater drainage, the experts intend to interact with hydrological cycle to enhance the protection of the watercourses and wetlands as described in Fig.1. The demarche consists of factoring into all planning the risk of floods, to not only create public spaces to harvest, clear and recycle water, but also manage the water in an environmentally friendly manner to contribute to biodiversity, carbon sequestration and reduction of urban heat islands. In clear, the noble ambition is to transform the drainage system from grey to blue green, and make Hong Kong progressing from a water supply city, sewered city, drained city towards a water sensitive city [5].

Adopted strategy in flood prevention and control is a comprehensive approach to tackle flooding risk from various fronts, from technical to management needs, and from short-term to long-term needs. It consists of setting up of flood protection standards which are comparable to major overseas cities and appropriate for Hong Kong's situation for new drainage works and for gradual improvement on existing drainage systems; carrying out comprehensive Drainage Master Plan studies to identify new drainage works and improvement on existing drainage systems; carrying out the identified new works and improvement works to bring their capacities in line with the flood protection standards as far as practicable; setting up of Drainage Authority under the Land Drainage Ordinance to be given legal power to protect major water courses in particular for those parts within private lots; addressing the drainage impacts brought by new developments under the well-established Drainage Impact Assessment mechanism; and, last but not least, carrying out comprehensive preventive maintenance of the stormwater drainage system to ensure their proper functioning [12].

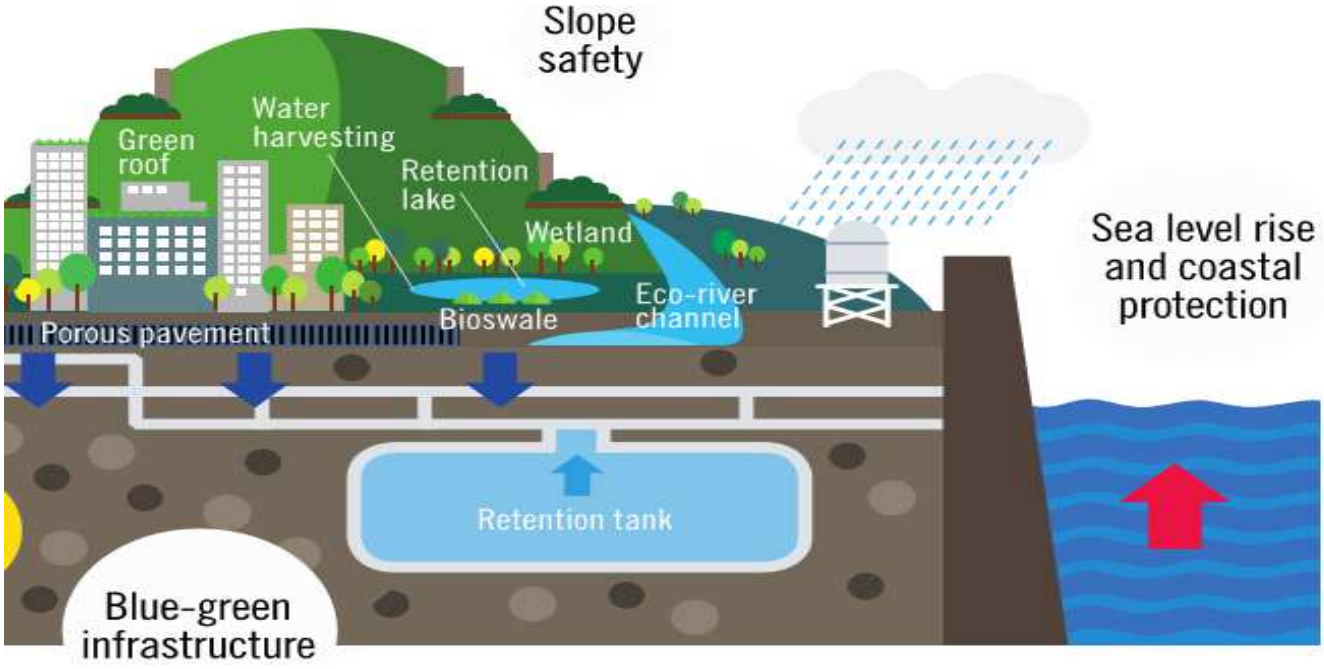

Fig.1 Development of Blue-Green Drainage System in Hong Kong

In the field of sewage collection and treatment, in order to cope with the rapid demographic concentration, the development and the rise in people's standard of living, the sewage infrastructure is now being upgraded under a territory-wide sewerage rehabilitation and improvement programme. One of the key projects is the Harbour Area Treatment Scheme (HATS), which aimed at not only improving the water quality of Victoria Harbour, but also providing a large scale sewage collection and treatment system. Under HATS Stage 1, commissioned in December 2001, sewage generated from Kowloon and northeastern part of Hong Kong Island is transferred by a deep sewage tunnel system to Stonecutters Island Sewage Treatment Works (SCISTW) for centralized chemically enhanced primary treatment before discharged into the western approaches of the Victoria Harbour.

The HATS Stage 2 is divided into Stage 2A and 2B. The Stage 2A aims to transfer the sewage generated from the northern and southwestern part of Hong Kong Island by a deep sewage tunnel system to SCISTW for centralized treatment before discharging; while the Stage 2B aims to adopt biological treatment in SCISTW to further improve the effluent quality [8].

In the Sewerage Master Plans (SMPs), the whole territory was divided into 16 catchment areas and the sewerage network and sewage treatment facilities are being upgraded on a catchment by catchment basis in order to improve the performance of the whole system. Some older sewage treatment works are also being upgraded. The Government is continuing to invest considerable resources in the sewerage infrastructure in order to improve the environment. Much effort is invested in combating water pollution in order to provide Hong Kong citizens with a safe and healthy environment [12].

As a result, about 93% of the population are now served by the public sewerage system. Such performance places Hong Kong as one of the well-connected countries in the world as shown in Fig.2. This system includes a sewerage network of about 1,700 kilometres in total length and around 300 sewage pumping stations and treatment facilities collecting and treating about 2.8 million cubic metres of sewage (enough to fill up 1,120 standard size swimming pools) per day from residential, commercial and industrial premises in the territory prior to disposal [12].

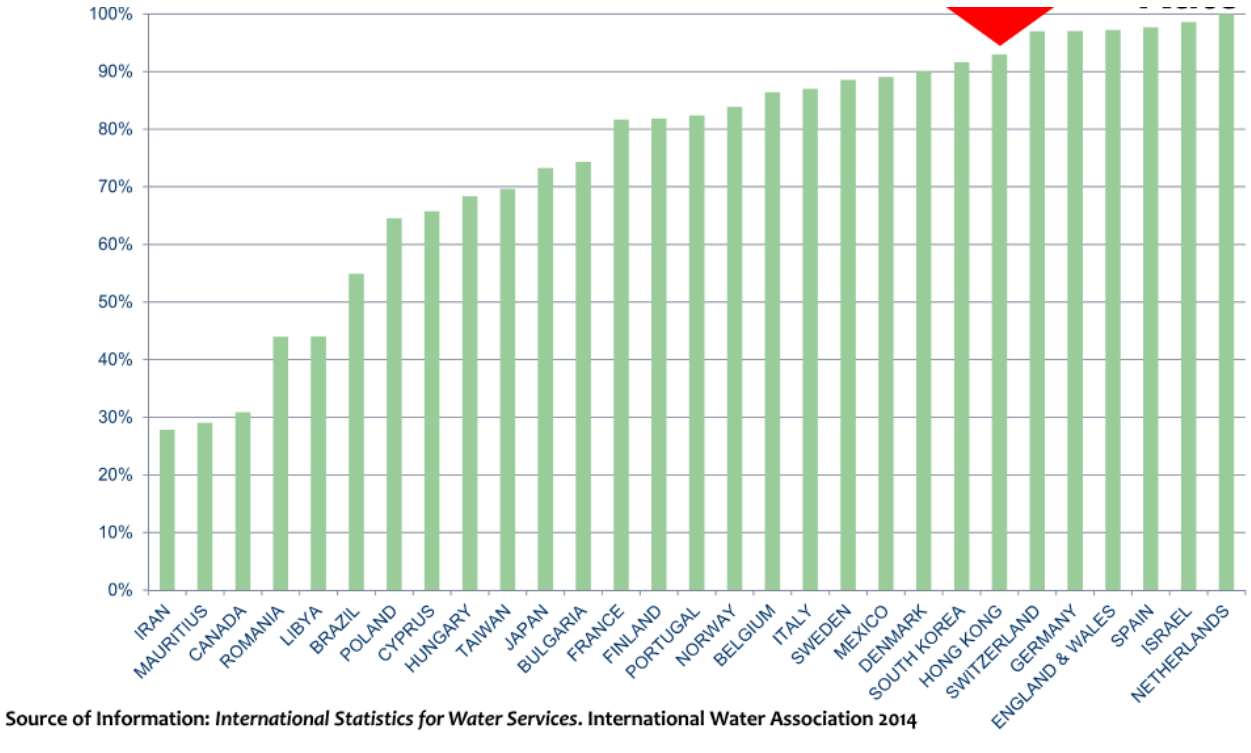

Fig.2 Comparison of Sewage Connection Rates in Diverse Countries in 2014

In addition to adopted rigorous environmental protection measures during sewage treatment, recognizing that green landscape enhances the quality of life, DSD has been conscious to apply greening effort to enhance the aesthetics of sewage treatment works, sewage and drainage pumping facilities which could be visually sensitive in their neighborhood.

The greening helps reduce visual monotony, enrich local biodiversity and improve microclimate such as providing shades, absorbing heat and reducing flying dust. Trees and flowers also provide a sense of seasonal change and increase aesthetic quality. Landscape treatment of the periphery could range from placing planters at the perimeter wall, allowing for a planting strip along the boundary to serve as a landscape buffer, providing vertical greening to soften building facade/structure, to building a podium or roof garden [12].

Landscaping within the sewage treatment works and sewage pumping stations elevates the ratio of green cover in the district. It also harmonizes the shapes, textures and colors of such utility service architecture. Greenery mediates concrete structures, buildings, tanks, pump rooms, pipeworks, boundary walls and open area. Notable examples can be found in Stonecutters Island Sewage Treatment Works, Shatin Sewage Treatment Works and Cyberport Sewage Treatment Works [12].

(2) Actions for Climate Resilience and Air Pollution Reduction in Hong Kong

Climate resilience is based upon assessment of climate change risks and vulnerabilities that Hong Kong is likely to face in the coming decades. In considering how to expand the city's resilience, Hong Kong Government is actively working with environmental experts to ensure efforts are well-coordinated. Security Bureau (SB) is coordinating Hong Kong's Contingency Plan for Natural Disasters, which is relevant for all extreme weather events that the community is used to encounter. Hong Kong climate adaptation response has been embodied in the Total Water Management Strategy [12].

In the field of flood prevention during extreme weathers, as shown in Fig.3 & 4, revitalizing water bodies has clear adaptation benefits, including integrating water bodies with urban landscapes to reduce heat island effect; turning "otherwise wasted" rainwater into useful resources; improving urban living environment, harmonizing human activity and nature; increasing resilience against the flooding brought about by climate change; and integrating drainage infrastructure with other land uses to improve carbon efficiency and reducing footprint [5].

Fig.3 Innovation in Flood Management System in Hong Kong

Fig.4 Green Flood Prevention System in Hong Kong

Proper management of the mangrove habitat is also a priority. A mangrove management plan was developed to achieve the dual purposes of reducing flood risk and protecting habitat, which required multidisciplinary collaboration between government departments (DSD, AFCD and EPD) and with non-government ecological experts. Existing climate resilience capacity has been strengthened with strategic plan to be implemented over the coming years on specific aspects including conducting studies on information gaps and monitor changes; strengthening institutional capacity and policy focus; carrying out drills; updating disaster and emergency planning from to time; improving dialogue and coordination with private sector and raising community awareness [5].

In terms of climate mitigation, the greatest potential for sizable quantities of carbon emissions abatement in Hong Kong lies in the strategies of coal usage reduction for local electricity generation and maximization of energy efficiency, especially in buildings. Current targets are to reduce carbon intensity by 50-60% in 2020 (baseline 2005); and to reduce energy intensity by 40% in 2025 (baseline 2005). Changing the fuel mix of electricity generation will undoubtedly help Hong Kong to create a cleaner power sector, reach the lower-bound of our carbon intensity target by around 2020, as well as improve air quality and public health arising from lower pollutant emissions. Supply side efficiency could be further improved through co-generation and tri-generation. The reduction of greenhouse emissions is basically

coupled with a programme of heavy air pollutants, in particular the roadside emissions. Current achieved performance is shown in Fig.5 [7; 12].

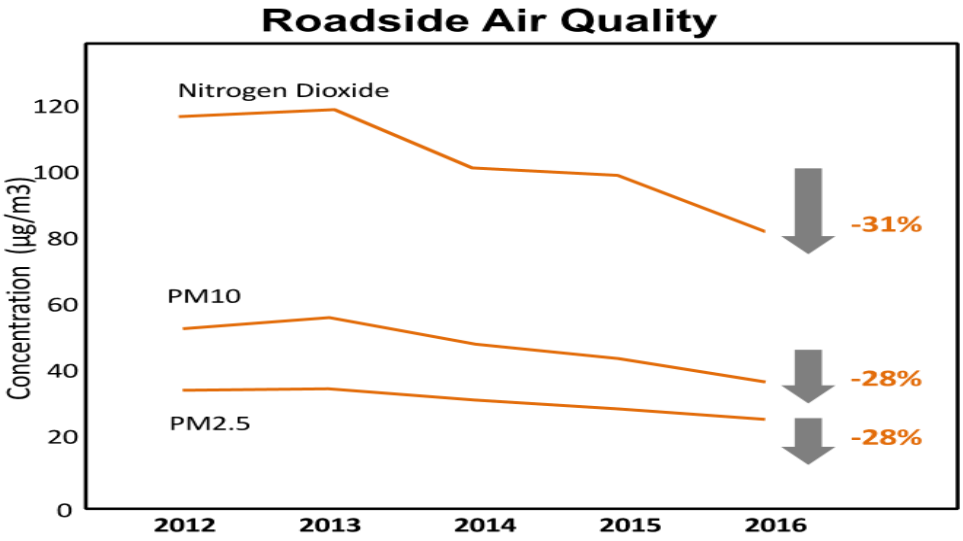

Fig.5: Hong Kong Roadside Air Pollutant Reduction Performance

In short, in collaboration with environmental experts from various horizons, Hong Kong Government is monitoring the implementation of climate mitigation measures on specific aspects including making public transport primary choice for mobility; expanding rail options and services; improvement of rail operation and vehicle fuel energy efficiency; testing low-carbon and zero emissions franchised bus technologies; recovery and use of landfill gas; recovering energy from sludge treatment; developing waste-to energy treatment for organic, yard and municipal solid waste; promotion of renewable energy such as solar power; improvement of power plant energy efficiency; promotion of co-and tri-generation; extension of lifespan of existing buildings with low carbon adaptive reuse; research on labelling and using low carbon construction materials and products; promotion of private electric vehicles; improvement of driving habits for fuel saving; promotion of biofuels use in government vehicles and non-road mobile machinery; capture and use of gas from wastewater treatment; and recovery of waste cooking oils for biodiesel production. The climate action is summarized in Fig.6. Beyond 2030, the ambitious long term target is to achieve a reduction of Hong Kong's carbon intensity by 80% in 2050 [7; 12].

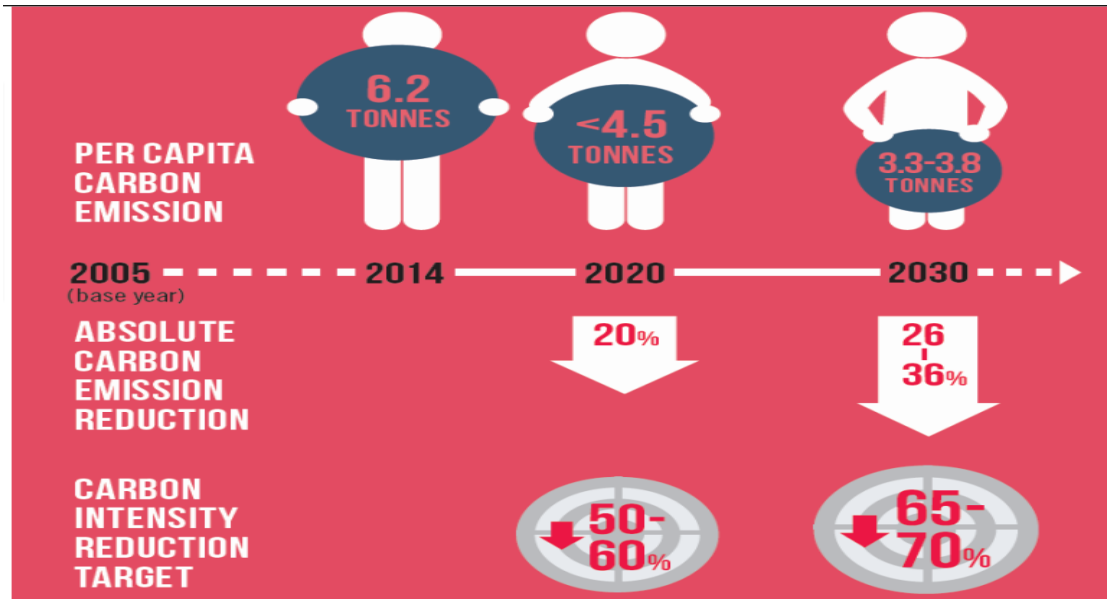

Fig.6: Climate Action Plan for 2030 +

(3) Creating Environmental Capacity for Sustainable Growth in Hong Kong

In an era of rapid social, economic and technological changes, Hong Kong as an international city in a globalised world is facing a number of multidimensional challenges both externally and internally as mentioned above. To embrace these challenges, the Hong Kong Government has embarked on an updating of the territorial development strategy, which is entitled "Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030" (Hong Kong 2030+) and seeks to, among others, optimise the symbiotic relationship between people, environment and nature [12].

Adopting a vision-driven, capacity creating and pragmatic approach, Hong Kong 2030+ envisions Hong Kong to become a liveable, competitive and sustainable Asia's World City under the over-arching planning goal of sustainable development. Three building blocks, namely planning for a liveable high-density city, embracing new economic challenges and opportunities and creating capacity for sustainable growth, are proposed for achieving the vision and overarching planning goal. Creating development capacity for a growing city needs to go hand in hand with creating, enhancing and regenerating environmental capacity by mainstreaming biodiversity considerations in planning decision and by improving our environment.

Hong Kong 2030+ advocates to uplift the liveability of the city through promoting eight city attributes: (1) continuing to underscore a compact, railway-based, efficient and convenient urban development model while addressing problems such as congestion and heat island effects; (2) integrating transport and land use planning to build an integrated city, with special attention given to enhancing walkability in the future; (3) accentuating the unique and diverse city characters; (4) promoting a healthy city and healthy lifestyle; (5) an inclusive city catering for the needs of all ages; (6) a city leveraging its rich diversity of green and blue assets to enhance public enjoyment, biodiversity as well as urban ecology; (7) a city with public spaces and public facilities reinvented; and (8) a city with rejuvenated and duly maintained urban fabric [6].

Currently, about 41% of Hong Kong population reside in the non-metro areas. Hong Kong 2030+ therefore seeks to create new economic nodes with critical mass of economic floor spaces at strategic locations outside of the Metro Area for bringing jobs closer to homes, synergising with planned developments, promoting Hong Kong as a base to serve the wider region, and leveraging opportunities to expand our development space [7].

The key strategic directions of Hong Kong 2030+ in creating capacity for sustainable growth include: (i) creating development capacity and optimising the use of land through a multi-pronged, robust and flexible approach and according a higher priority to releasing degraded areas as well as sites at the fringe of built-up areas that are deserted or have low conservation, buffer and public enjoyment value; (ii) optimising transport and other infrastructure capacity through the provision of new or improved infrastructure, wider use of public transport, demand management and better home-job balance; (iii) improving the environment and creating/enhancing/regenerating environmental capacity through integrating conservation and biodiversity considerations into planning and decision making as well as improving the environment; and (iv) adopting a smart, green and resilient (SGR) city strategy that permeates all aspects of land use, transport and infrastructure planning for building a low-carbon and future-proofing city, supported by a common spatial data infrastructure (CSDI) and information and communications technology (ICT) infrastructure, as described in Fig.7 [12].

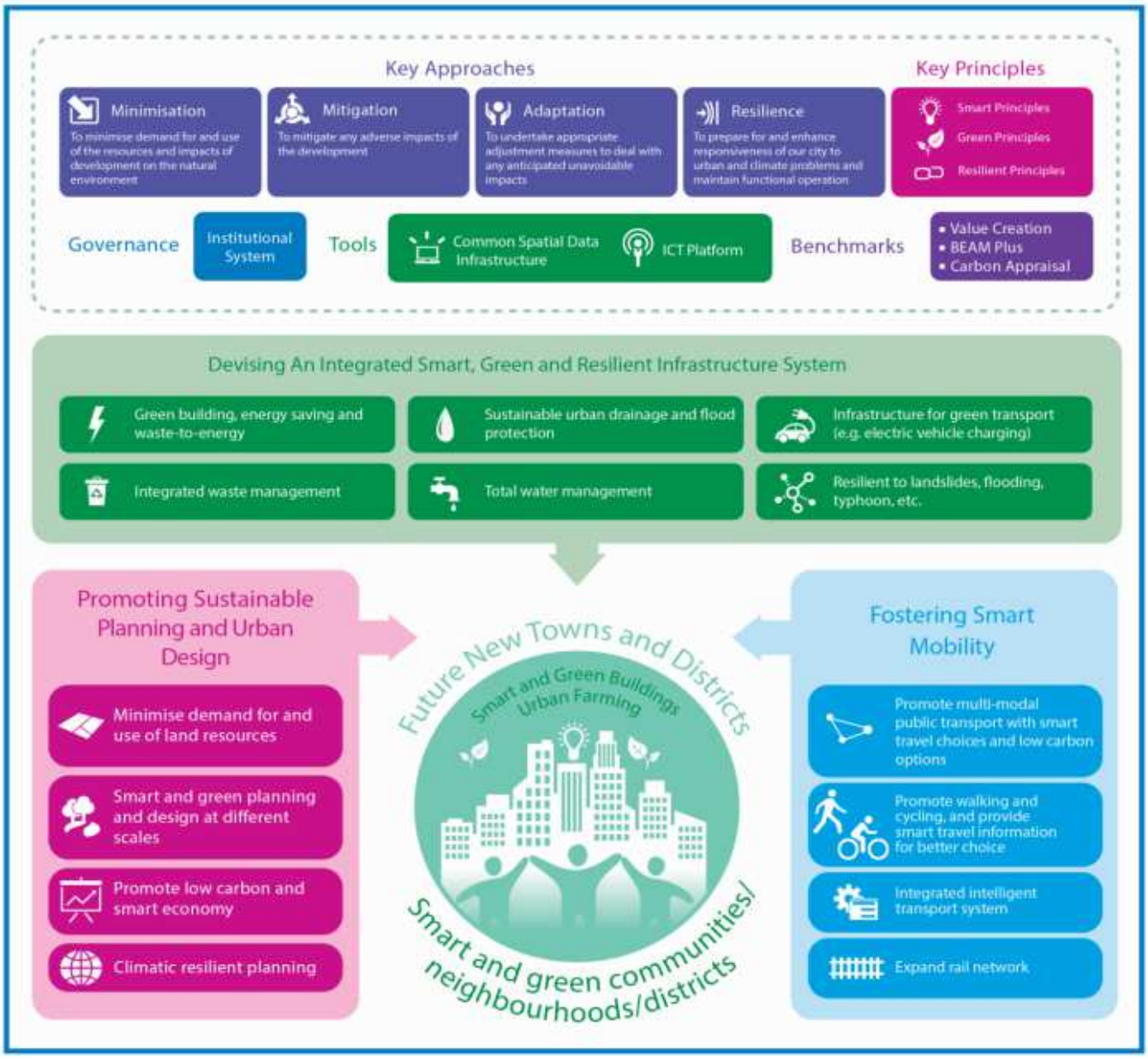

Fig.7: General Smart, Green and Resilient City Framework for the Built Environment

(5) Innovative Biodiversity Action Plan

In line with the sustainability vision of Hong Kong 2030+, the key actions under the biodiversity action-plan are summarized as follows [12]:

-Maintain and enhance the management of protected areas: maintain and enhance the management of country parks, special areas, marine parks, marine reserve, Ramsar Site and SSSIs for biodiversity conservation.

-Conserve ecologically important habitats outside the existing protected areas: enhance existing practices on the identification of ecologically important habitats outside the existing protected areas, and consider appropriate measures to protect and/or manage these habitats.

-Enhance conservation of natural streams: protect and conserve natural streams and their riparian zones, and avoid pollution of streams.

-Maintain habitat connectivity for wildlife: establish and maintain ecological corridors to promote habitat connectivity for wildlife; step up enforcement against wildlife crime; enhance protection of threatened species through strengthening enforcement effort and coordination with the relevant departments.

-Implement conservation action plans for priority species: formulate and implement conservation measures and action plans, including both in-situ and ex-situ conservation, for species of conservation concern, in particular highly threatened and important species.

-Improve management of invasive alien species (IAS): study the impacts of IAS in Hong Kong, and implement monitoring, management and control plans for the target IAS identified; control the environmental release of genetically modified organisms (GMOs): monitor and control the environmental release of GMOs for managing the risks on local biodiversity.

-Incorporate biodiversity considerations in planning and development process: continue to enhance the consideration and appraisal of strategic environmental and sustainability issues in major planning and sectoral studies to facilitate integration and coordination of biodiversity conservation.

-Promote biodiversity in urban environment: promote biodiversity in our urban landscapes, through increasing diversity of complementary species for works projects, and promoting appreciation for the socio-economic benefits that biodiversity generates in healthy urban ecosystems.

-Promote sustainable fisheries: designate Fisheries Protection Areas(s) (FPA) to protect important fish spawning and nursery grounds, as well as continue existing measures for sustainable management of fisheries resources.

-Promote sustainable agriculture: promote sustainable agriculture in Hong Kong through encouraging environmentally and biodiversity friendly agricultural practices.

-Conduct biodiversity surveys: conduct long-term territory-wide biodiversity surveys and monitoring; conduct species assessment: assess the conservation status of species in Hong Kong to guide conservation actions; collate information on terrestrial and marine habitats, to identify ecologically important habitats, assist monitoring of status and trends, and guide conservation actions.

-Improve sharing of knowledge: improve the sharing of knowledge of biodiversity, by developing a web-based information hub and a centralised database; identify services provided by our ecosystems, with a view to safeguarding and restoring important ecosystems to ensure the provision of these services.

-Enhance understanding of traditional knowledge: study, take stock and consider the adaptive use of traditional knowledge relevant to conservation and sustainable use of the biodiversity in Hong Kong, through engaging the local communities.

-Provide and coordinate financial support to research and studies for advancing our knowledge in priority areas; promote the awareness of biodiversity, in particular through partnering with the wider NGO community, business and other sectors.

-Promote biodiversity in education: incorporate the concept of biodiversity into the school curriculum and provide capacity building for teachers on biodiversity; promote the sustainable consumption of biological resources.

In addition, specific actions highlighted below, should be considered and implemented to provide a quality living environment and enhance biodiversity in Hong Kong [12].

-Identifying riverine areas for conservation / enhancement / revitalisation: riverine areas should be appropriately integrated in urban development. In this way, ecological enhancement and environmental considerations should be embodied in designing drainage infrastructure projects.

-Adopting eco-shorelines for new reclamation: eco-shoreline elements should be integrated in reclamation in order to restore the beneficial use and ecological function of the existing natural shoreline.

-Agricultural land conservation / revitalisation: revitalisation of abandoned farmland could bring ecological benefits. Opportunities for agricultural land conservation / revitalization in many parts of Hong Kong could be explored for biodiversity enhancement, among other benefits, in Government's initiatives for establishing agriculture priority areas.

-Enhancing the urban forestry management strategy during planning, design and implementation stages of public sector landscape related projects since, in addition to a wide range of environmental and social benefits. Urban forests can also serve as important ecological linkages with the countryside and encourage movement of wildlife among different parts of the territory.

In short, the action-plan drives urban liveability, serves human needs, adds value to infrastructure, lessens local resistance, enhances public acceptance, increases resilience and promotes sustainability. This calls for partnership between Government and key stakeholders for mainstreaming, commitment and innovation. Biodiversity is essential not just to improve environmental quality in cities, but also promotes health and well-being of their inhabitants and social capital [12].

3.2 Experiences from Dunwell Enviro-Tech Holdings: Sewage and Industrial Wastewater Recovery

One of advanced environmental technology firms revealed during the Annual Forum is Dunwell Enviro-Tech Holdings Limited. Established in 1993, Dunwell has come to stand for advanced technology, high quality and excellent customer services. Dunwell has captured the booming of Hong Kong economy and lived through various economic and political cycles. Currently, Dunwell business covers oil, solvent re-refinery, manufacture, trading and marketing of lubricants, environmental-related technologies, precision of metal components, industrial equipment, lubricating oil analysis services, and specific chemicals. In view of the extreme and uncertain weather, the development of innovative and practical solutions on water management is essential. The speaker examined and shared with participants various technologies in recycling and reusing wastewater in both industrial and residential sectors in Hong Kong and China [2].

(1) Development of Zero Liquid Discharge Technology for Resource Preservation

Dunwell is taking market advantage from increasing regional stringent environmental regulations, in particular in Mainland China. In fact, China published a development plan for energy saving with stringent environmental protection in 2012. One of the key areas in this plan is wastewater recycling driven by strict regulation on wastewater discharge. Pharmaceutical, petrochemical, energy and food industries are the main targets on the highest standard of such regulation well known as Zero Liquid Discharge (ZLD) [2].

While most of industrial processes generate a wastewater stream, the objective of a ZLD system is to recover and reuse all water, to avoid emissions. The restriction of wastewater discharge requires water recovery processes involving biological and chemical treatment, membrane filtration, concentration, and finally evaporation. The process is briefly described below:

-Pre-treatment: the wastewater is filtered using membrane technology such as ultra or Nano filtration and then through the Vibrating Membrane (VMAT); the water stream is thus directed through porous membranes into a permeate.

-Evaporation: concentrate from filtration enters a brine concentrator which is a mechanical evaporator using a combination of heat and vapour compression to evaporate the brine solution, resulting in a wet sludge.

-Crystallization: the crystallizer converts the sludge to solid waste with high pressure steam which further evaporates the water and facilitates formation of crystals. Any remaining water should be therefore clean enough for reuse.

The solid content known as 'salt cake' can then be disposed of according to its constituents, which in turn depends on the nature of the original industrial processes. For the most toxic type of wastes such as biocide concentrate from the pesticide or pharmaceutical industry for example, incineration is usually the safest mode of disposal. Some hazardous waste can be treated in a specific waste treatment unit such as a hazardous waste treatment plant. Unfortunately these types of units are not widespread in China and eventually the hazardous waste may be disposed of to landfill. Less hazardous waste from power plants on the other hand can be disposed of to landfill. In rare cases, the waste is homogeneous enough to be considered as a by-product and can be reused directly as industrial salt [2].

The process is relatively energy efficient. Moreover, to save costs and reduce the capacity needed, comprehensive water audits are usually performed which also ensure that the system deals only with the most polluting streams. Installing ZLD technology is therefore often beneficial for the water management; encouraging operating departments to detail water usage, avoid wastage and spur recycling by conventional and far less expensive solutions. However, when considering ZLD, the capital cost necessary for installing an evaporator and crystallizer can be prohibitive. Dunwell has developed appropriate software to optimize related cost and accessory needs [2].

Currently, Dunwell is operating such technology in Mainland China (Fig.8). As stated by the speaker, it is a great chance for Hong Kong environmental industry to grasp such business opportunity and connect to the Mainland market [2].

Fig.8 ZLD Pilot Plant for Coal Gasification in China

(2) Implementation of A-JET Aeration Treatment Technology

A-Jet aerators are applied across a wide range of water, wastewater and biosolids treatment applications. Their primary purpose is to transfer oxygen to the liquid or sludge (Fig.9). Technically, A-jet aerator works through aspirating technology by simultaneously introducing large volumes of high kinetic energy liquid and air through one or more jet nozzles. The high velocity liquid exits the inner, primary jet and rapidly mixes with the incoming air in the outer jet. This intense mixing and high degree of turbulence in the gas/liquid cloud travels outward from the jet along the basin floor prior to the vertical rise of the gas bubble column to the liquid surface. A-Jet aerators have high oxygen transfer and higher alpha values compared to other aeration devices. Jet nozzle gassing rates can vary significantly without major changes in oxygen transfer efficiency. A-Jets also provide high energy efficient off-bottom solids suspension. A-Jet aeration technique can replace the air blower or compressor by a centrifugal pump and nozzle while provides 50% energy saving with the same amount of airflow. In short, jet aeration systems for wastewater treatment come up with following benefits [2]:

-Eliminating tank bottom diffusers and replacement
-Low installation cost
-Low energy cost
-Low maintenance cost
-High oxygen transfer efficiency
-Long-term and stable efficiency
-High mixing capacities, without extra mixing and extra oxygen supply (anoxic periods)
-No aerosols
-No pre-cooling of the aerated liquid
-Frost unsensitive
-Low foam formation sensitivity
-No moving parts in the aeration basins
-Very suitable for use in deep aeration basins
-Obstruction unsensitive
-Reduced off-gas volume
-High process performance
-High corrosion and abrasion resistance

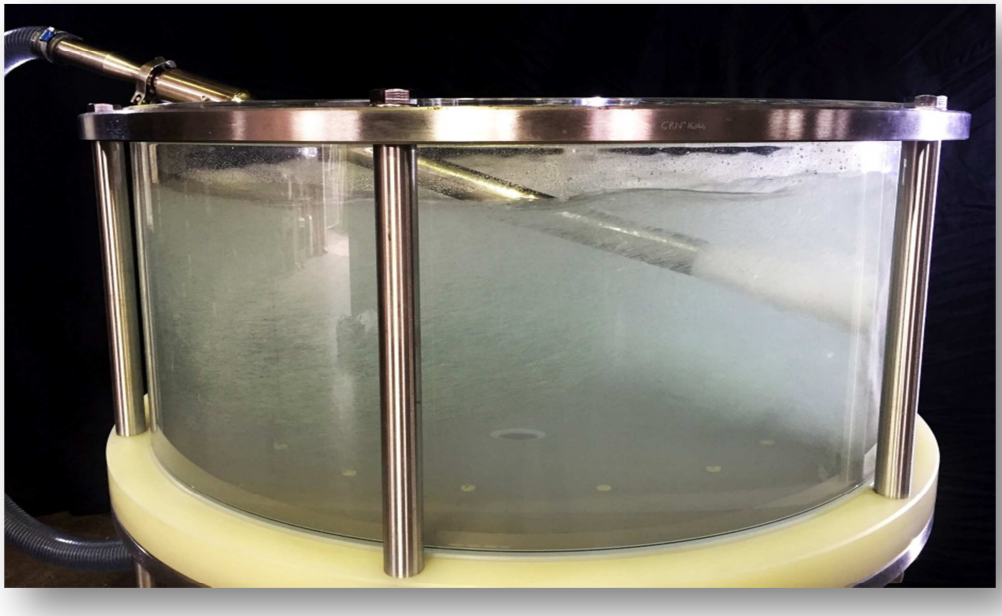

Fig.9 A-Jet Aeration Technology

(3) Development of Wastewater Vibrating Membrane Treatment

The membrane technologies have been one of the most used technologies for the treatment of water over the last two decades, and are considered as a very high performing system. However, the system also presents a common problem, which is the sealing caused by the residue layers that accumulate on the surface of the membrane during the filtration process. To resolve this problem, vibratory membranes VR have been developed (Fig.10). The main difference compared to traditional membranes is that the basic design is vertical instead of horizontal, which means that the space required per unit is less than for other separation systems [2].

As underlined by the speaker, the vibrating membranes are capable of filtering any type of wastewater and can treat effluents with a high load of solids. In addition, it is a technology that does not require chemicals for operation, apart from those that are necessary for periodic cleaning of the membrane. In a VR Membranes system, the liquid to be treated is almost immobile, circulating slowly between the elements of the parallel membranes. The cleaning action of the shear is created by vigorously vibrating the elements of the membrane in tangential direction to the surface of the membranes.

The shear waves produced by the vibration of the membrane, mean that the solids are made to rise to the surface of the membrane and that they are once again mixed with the material or effluent that moves inside the membrane. This intense shear allows the pores of the membrane to be cleaner, achieving a higher performance than conventional membranes. Vibratory membranes enable to recuperate around 90% of the treated water as clean water that can be emptied or reused. The type of membrane that is used in VR systems varies depending on the effluent to be treated. A very general classification would be as follows:

-Reverse osmosis membranes for the separation of materials
-Nanofiltration membranes for the treatment of wastewater and for concentration
-Ultrafiltration membranes for oil separation and concentration
-Microfiltration membranes to separate the biggest particles from a liquid phase

Other important parameters are pressure, temperature, amplitude of the vibration and the time of residence of the material inside the membrane. All of these parameters are optimized during initial tests and are then recorded in a PLC that controls the system automatically. In addition, the VR is a modular system that is flexible and can be modified after installation with following characteristics [2]:

-It can be added easily to an existing system to improve the performance
-It can be installed in areas where space is limited
-It is easy to transport and can be moved from one plant to another
-It can be installed in multiple systems or phases as a single step
-More units can be added in accordance with the increase in production

Fig.10 Wastewater Vibrating Membrane Treatment System

3.3 Learning from Mainland China: OceanAlpha USV Applications for Environmental Innovation

Founded in 2010 in China, OceanAlpha is the leading and largest Unmanned Surface Vessel (USV) Company in the world. OceanAlpha employs more than 100 engineers and holds 92 USV related patents. OceanAlpha has developed more than 25 models of USVs varying from 1m to 50m. The USV is equipped with survey instruments such as water quality probe, echo sounders, side scan sonar, etc. to conduct innovative environmental measurement, hydrology and hydrographic survey, oceanology investigation, surveillance & rescue and cargo shipping [4].

In addition, unmanned surface vehicles (USVs) has been introduced to the oil and gas industry and offered a variety of solutions that aided in lowering costs and improving the efficiency of offshore operations. OceanAlpha has been working with oil and gas customers to provide innovative USV solutions that meet the requirements of the offshore surveying sectors. The USV are capable of conducting subsea positioning, surveying and innovative environmental monitoring, and can be integrated with a variety of offshore payload combinations including: USBL, ADCP, CTD, Multibeam Sonar, and sub-bottom profilers. OceanAlpha USVs can also be utilized in the patrol missions around drilling platforms. The portfolio of OceanAlpha products and the application scenarios are shown in Fig.11 & 12 [4].

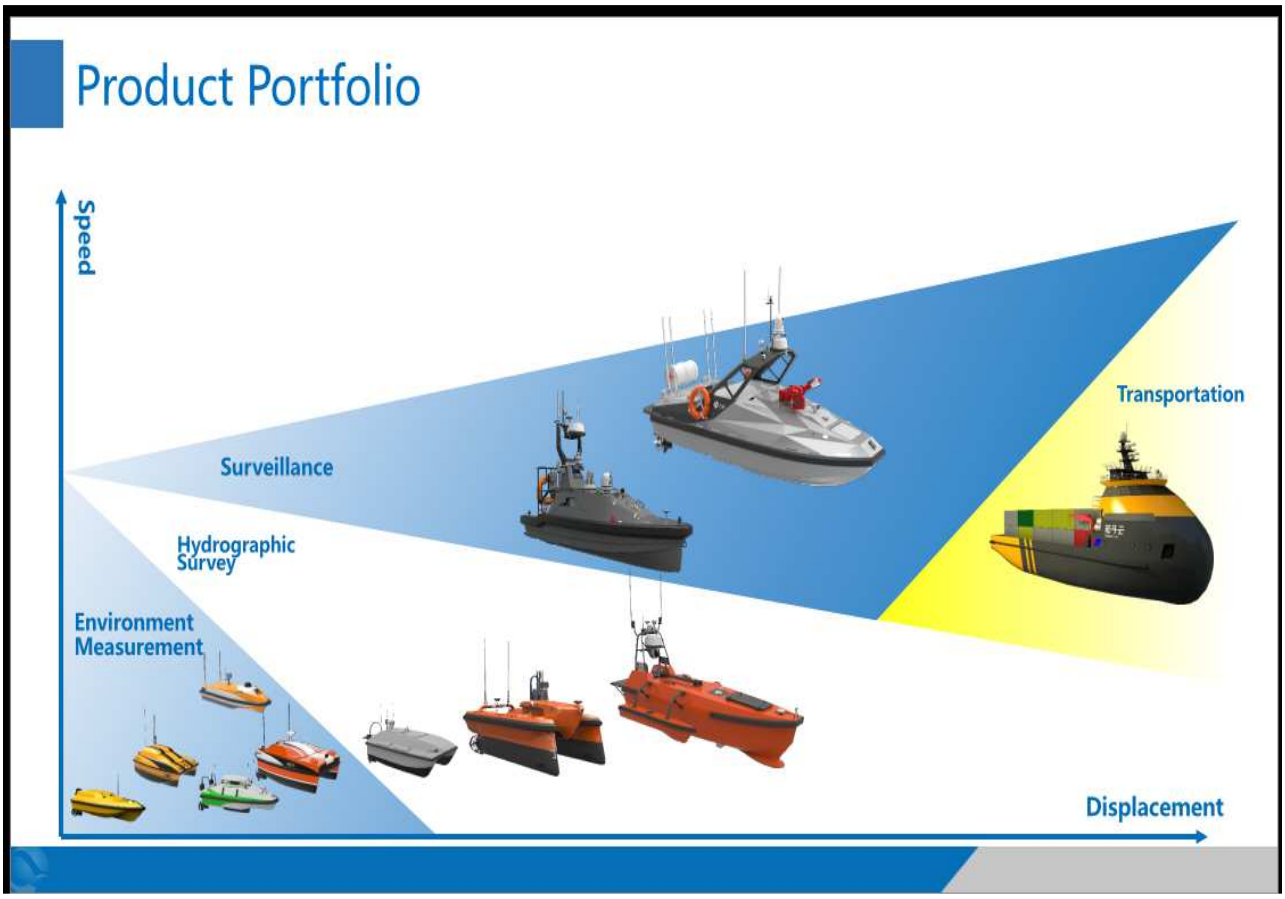

Fig.11 OceanAlpha Product Portfolio

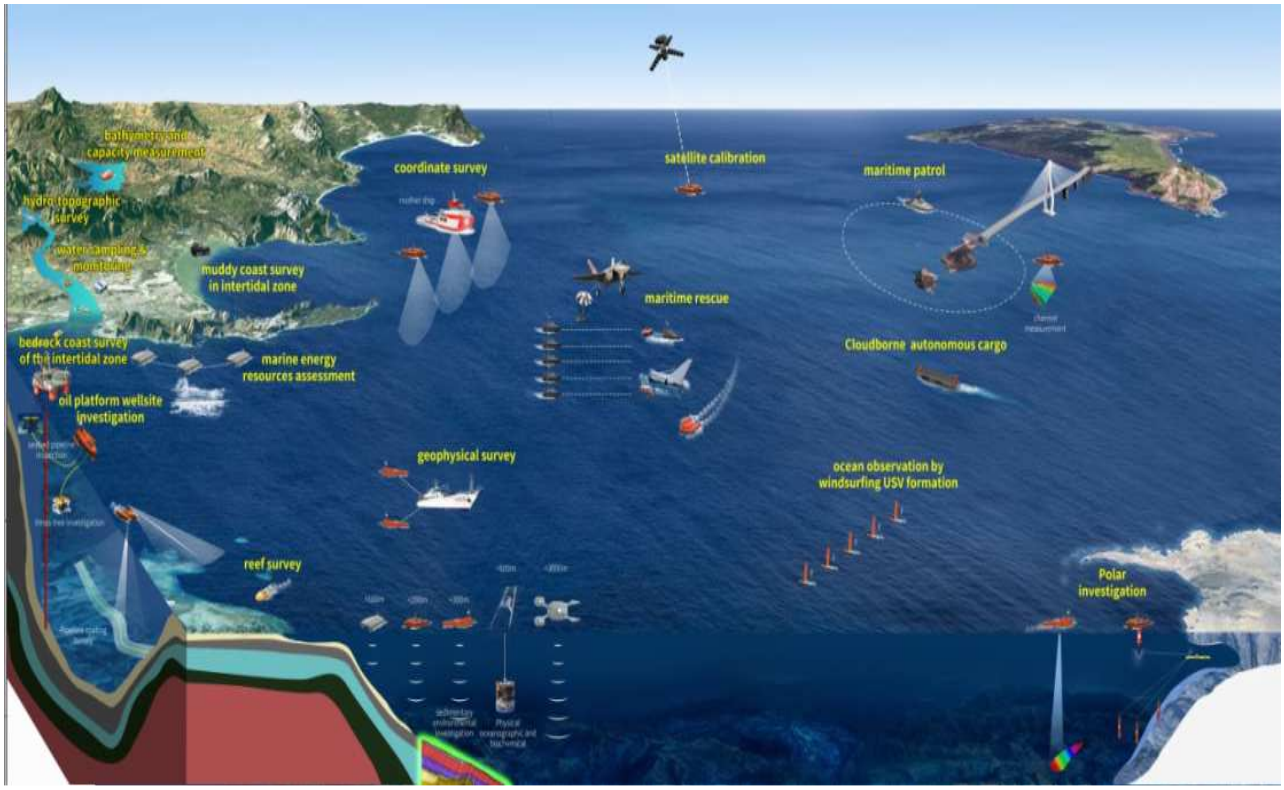

Fig.12 Application Scenarios of OceanAlpha USV

(1) Innovative Water Quality Assessment & Sampling for Pollution Mitigation

OceanAlpha makes unmanned surface vessels (USVs) for water quality professionals that innovatively sample, monitor, or survey large areas of water surfaces. The use of a USV reduces the amount of time, labour and equipment needed to collect water quality data when compared to traditional methods. Agencies have seen more than six times more improvements in efficiency in comparison with traditional manual methods, while simultaneously reducing risk by keeping technicians and full-sized vessels on shore. The USV accurately describes and innovatively elucidates the water quality, pollution risks in all aspects, and provides the decision makers with potential insights for environmental innovation (Fig.13).

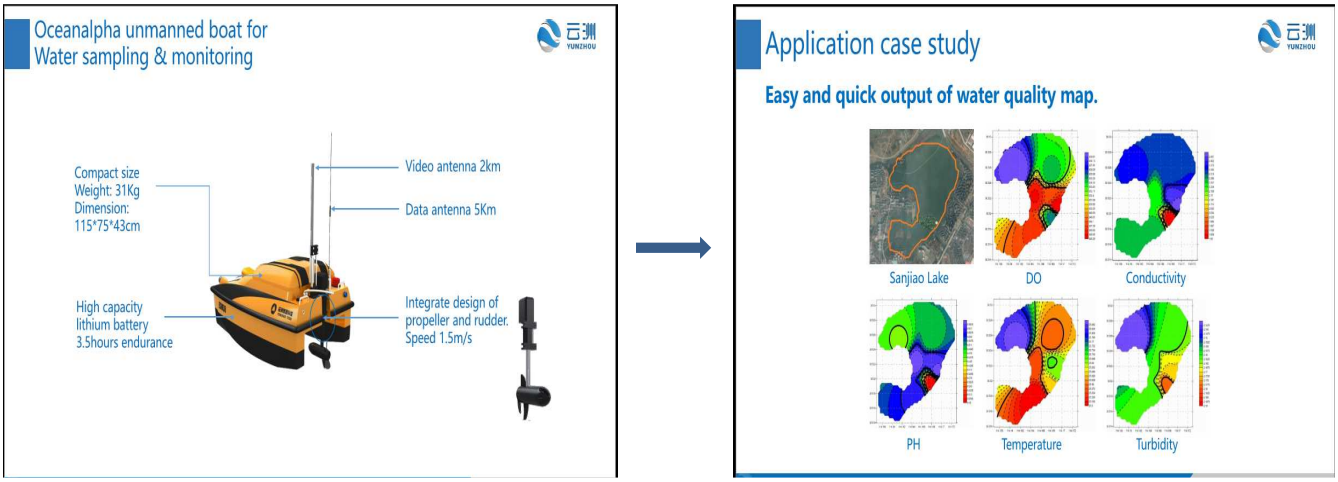

Fig.13 USV Hydrographic Survey Application

Manually tracking and revealing pollution sources is one of the most arduous part of pollution remediation which is often conducted with low efficiency, high cost and would post huge potential safety hazard to surveyors. As an innovation, the application of unmanned surface vessel technology substitutes human being in working in complex or severely polluted water environment and guarantees the high quality of survey data and success of mission with its great functional stability and matured technology. The application of OceanAlpha's USV is a real technological revolution to the traditional operation of water quality and sewage outlet remediation, which particularly suits the need of city management in environmental monitoring and pollution investigation with potential preventive capability [4].

(2) Unmanned Surface Vessels for Hydrographic Survey

OceanAlpha's autonomous hydrographic surveying boat has been applied to the mining industry for tailing dam ponds and tailing storage facilities (TSFs) and has been employed in more common applications such as lakes, rivers, reservoirs and oceans. The survey way-points and the boat automatically begin surveying and acquiring online bathymetric data using its built-in GPS navigation system. USV surveying technology has been proven to be a great alternative to replace traditional manned surveying techniques, especially those that are repeated periodically or in hazardous water (Fig.14). Generating quality data, cost reduction and saving human lives make the OceanAlpha solution more appealing to mining companies when they make survey decisions [4].

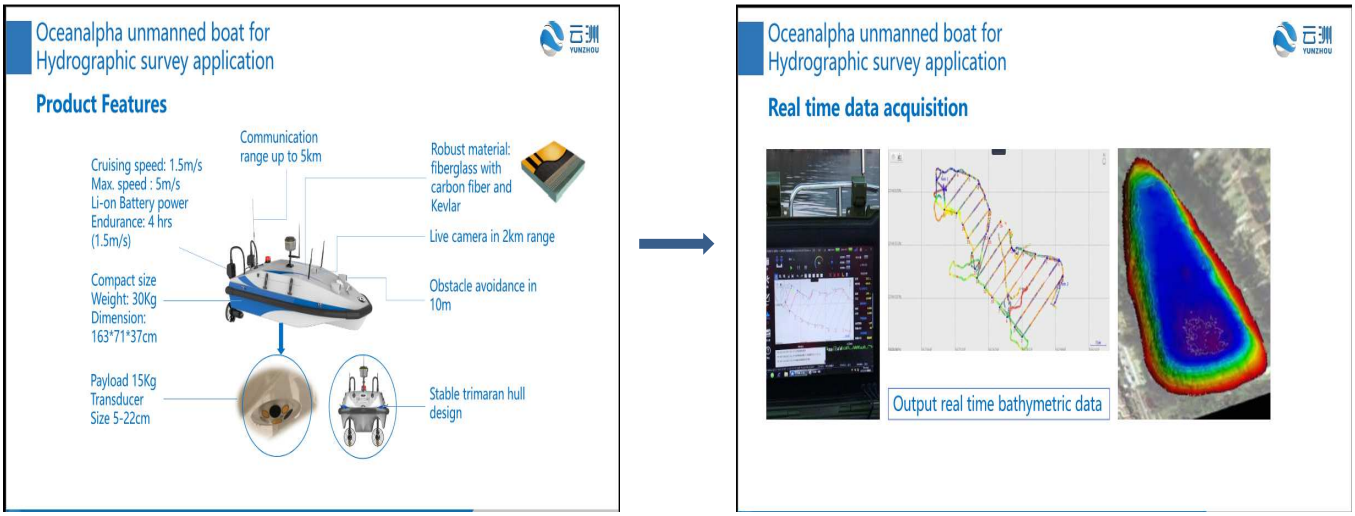

Fig.14 USV Hydrographic Survey Application

3.4 Learning from Netherlands: Environmental Innovation at the Port of Amsterdam

The Port of Amsterdam is one of the largest energy ports in Europe. The port management is fully aware of the port's environmental impact on the surrounding area and the climate. The need for energy transition and lower port emissions offers room for new opportunities. As a result, the port opts for sustainable growth, and intends to be one of Europe's leading sustainable ports by 2030. First and foremost, as a responsible organisation the port management strives to be a role model by minimising CO_2 footprint and promoting business sustainability. In addition, the management works with clients on a platform that minimizes pollution with environmental innovation. A summary of the environmental innovation and sustainability vision at the port of Amsterdam is displayed in Fig.15 [11].

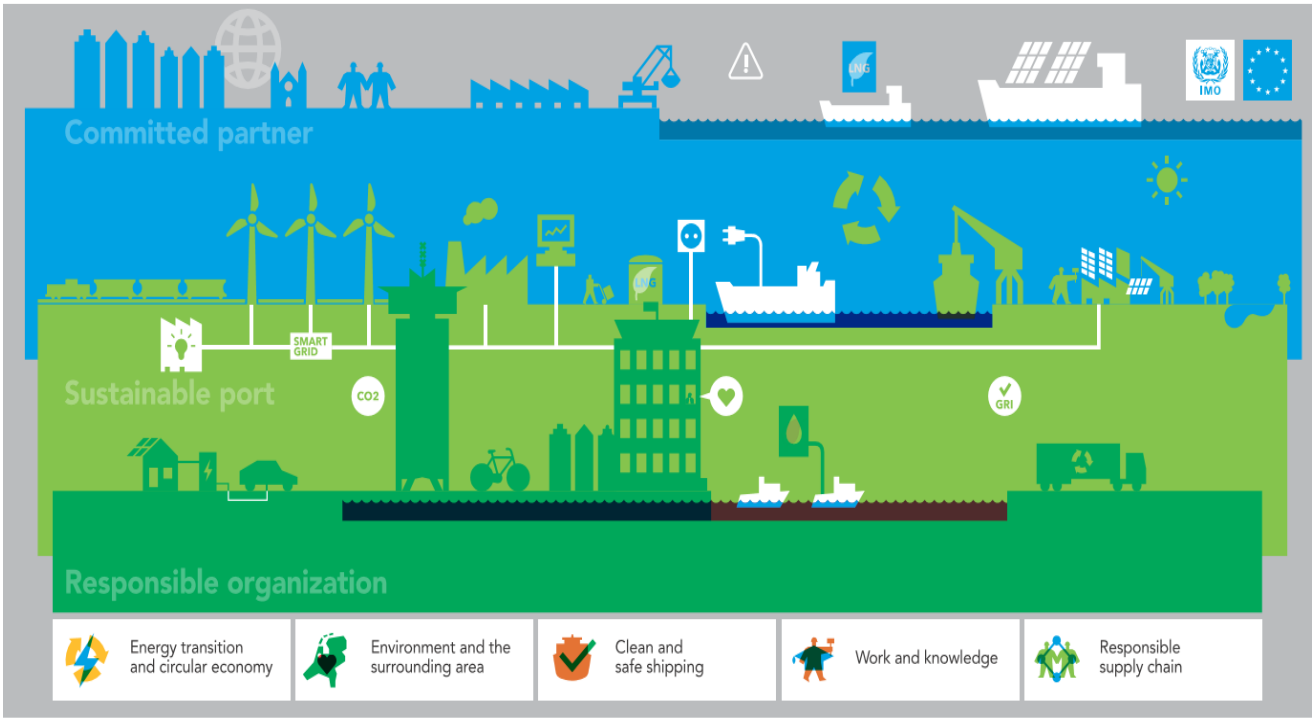

Fig.15: Sustainability Vision of the Port of Amsterdam

(1) Energy Cycle with the City

Renewable energy sources are becoming an increasingly realistic alternative to a number of fossil fuels (especially with regard to electricity generation) and are quickly acquiring a place in the energy system. The port's connection to the city offers an effective basis for an energy cycle that converts waste flows from the city into new raw materials and fuel. The main objective is to use energy and waste intelligently to achieve a cleaner ecosystem [11].

(2) Shipping Cleaning and Drastic Emission Abatement

Emissions produced by shipping in the form of sulphur, nitrogen, particulate matter and CO_2 represent a significant share of emissions in and beyond the port region. Particular attention has been paid to ballast water, underwater noise, ship waste, the degassing of volatile organic substances and ship recycling. Shipping is significantly cleaned in order to continue to represent a sustainable solution to logistic needs and legislation. The port authority potentially rewards sustainability and thus makes a contribution to the policy reform.

The authority aims to reduce CO_2 footprint by 25% in 2021 in comparison to the level of 2014. This implies a reduction of 591 tonnes of CO_2 (from 2,364 tonnes in 2014 to 1,773 tonnes in 2021). Hybrid company cars have been thus introduced. The port building's renovation resulted in a significant reduction of greenhouse emissions and heavy air pollutants.

The modernisation of the feet also represented a major contribution to the reduction of emissions. In 2016, a pilot programme of sustainable fuel has been launched with 30% mixing hydro-treated vegetable oil fuel (HVO, using cooking oil) for the patrol vessels, resulting in a direct reduction of 14% of CO_2 reduction.

(3) Development of Sustainable Energy Supply

Sustainable energy supply development of the port of Amsterdam is achieved using a step-by-step approach, in association with clients and partners. The aim is to gradually shift the balance between fossil fuel and non-fossil fuel cargo by increasing the share in renewable energy and other non-fossil fuel markets. Significant progress has been made in the generation and storage of solar and wind power. The aim is to have 100.000 m² of solar panels installed at the port.

The port is able to supply sustainably generated energy to all clients. Together with the Municipality of Amsterdam opportunities have been found for installation of more wind turbines in the port region. In 2012, a joint Westpoort Wind Vision has been established with the municipality to provide new search locations. Following a provincial moratorium in 2015, the port authority was able, along with Windgroep Holland and Waternet, to submit principle applications to the Province of Noord-Holland for the development of new wind farms in Westpoort. It concerns new rows of wind turbines and additions to, or the replacement of, existing rows. By 2021, the port aims to achieve a wind power capacity of 100 Mega Watts [11].

With a collaborative power, the port management has united supply, demand and technology by developing a smart grid: a flexible, decentralised energy infrastructure in the port region. A prime example is Clean Capital, a cooperation partnership between the Port of Amsterdam, Afval Energie Bedrijf Amsterdam (AEB) and Waternet, which focuses on innovative projects in the field of sustainable energy and raw materials.

This resulted in the supply of the development of green and sustainable energy sources in the port. A grant was requested and approved for 15,000 m^2 of solar panels on the roofs within the port in 2016. In 2017, this amount has been doubled to 30,000 m^2. By 2020, the port is aiming to achieve 100,000 m^2 of wind farm [11].

(4) Switching to Biobased and Circular Economy

The port Authority has achieved significant investments that were necessary to switch to a biobased and circular economy and align the supply and demand of waste flows. New business models and innovations enable the port to convert raw materials or waste into energy and retain them in the industrial cycle with installation of necessary infrastructure.

Various recycling processes have been introduced for waste recovery. For example, Waternet extracts phosphate from urine in sewage water to produce fertiliser; Orgaworld Biodiesel Amsterdam, NOBA and Rotie convert cooking oil and other organic waste into green power, biodiesel and heat, to heat thousands of homes in Amsterdam. Enhancing the value of waste flows from the Metropolitan region and the city as much as possible in the port is an important goal. Innovative joint research has been conducted on a steam pipe network, processing technology for fluid waste and the production of biobased materials and chemicals. Concretely, the port aims to achieve 22,5 hectares of new land to start-ups with innovative concepts in the biobased and circular economy by 2021 [11].

(5) Innovative Green Deal for Water Pollution Prevention

As part of the Innovative Green Deal Ship Waste Chain, the port Authority strives to limit the amount of waste on board along with Dutch seaports and other partners (including the North Sea Foundation and the Central Government) by focusing on waste prevention to phase-out water pollution. Enhanced improvement of plastic waste and other wastes sorting on the boarder and within the port has been achieved. Since January 2016, skippers can hand in their waste at Dutch ports for free. A total of 40,000 m^3 of waste was collected in 2015 for recycling in order to avoid water pollution in the port region [11].

(6) Development of Sustainable Procurement

Innovative criteria have been applied for sustainably responsible procurement relating to installing infrastructure, managing the port region and premises. A sustainable procurement policy has been developed in 2017, involving emission reduction, green innovation, material recycling and recovery, circular economy and social return.

3.5 Learning from Australia: Data-Driven Environmental Innovation

CSIRO, Australia's national science agency, has been solving the nation's greatest challenges with solutions from science for over 100 years. To create a better world for the future generations, CSIRO is bringing together the innovation ecosystem and building a global applied R&D network of partners in government, industry and academia called the D61+ Network.

CSIRO's Data61 was officially formed in 2016 from the integration of CSIRO's Digital Productivity flagship and the National ICT Australia Ltd (NICTA). Through the D61+Network CSIRO aligns collective capabilities with Australia's national interests and help Australia create new technology-based industries that can reach global scale [9].

(1) Urban Environmental Challenges in Australia

Australia's cities are dynamic and considered among the most liveable in the world, but are facing a growing number of challenges. These include changing population and demographics, increasing urban heat, lacking renewable energy, critical environmental sustainability issues, rising social inequalities, ageing and inadequate infrastructure, growing resource consumption and waste, declining housing affordability, adapting to the impacts of climate change, responding to technological disruption, etc.

Climate change threatens the liveability of cities, further exacerbated by fast urbanising coasts where most of the Australian population lives. Cities are facing increasing challenges of weather-related disasters, flood, typhoon, which damage buildings and infrastructure services including water, energy, transport, and

telecommunications. For example, cyclones and storm surges destroy houses, bushfires rage at the urban fringe, and heat stress, vector borne and other climate related diseases pose health risks.

The impacts of a changing climate add to existing challenges such as urban sprawl, aging infrastructure, population growth, pollution and the loss of biodiversity. As the complexity of urban systems increases, there is a growing role for science to inform and transform the process of urban development and renewal.

(2) Science and Data for Urban Environmental Innovation

CSIRO's Data61 achieved a strong track record in delivering scientific solutions to urban sustainable development and resilience under changing climate and disasters. CSIRO's Data61 applies skills and experience to help Australian cities and coastal communities prepare for the impacts of climate changes, while also reducing the urban greenhouse gas emissions and improving long term sustainability [11].

A key process is the urban living labs. The idea of urban laboratories has come from several years of informed discussions with industry and government agencies about the future of cities. Urban Living Labs provide a 'safe space' for collaboration and a testbed for environmental innovation, going beyond business-as-usual and demonstrating the potential of alternative ways of thinking. To maximise learning and opportunities for innovation, CSIRO is developing a portfolio of Urban Living Labs that span a range of urban development types and environmental contexts across the country. Undertaking research in real-world contexts enables the evaluation of the wider outcomes of the labs in terms of empowering the community, delivering integration, and monitoring the broader benefits and impacts of the urban innovations tested [9].

On the other hand, the Insight Team at Data61 analyses emerging environmental trends, drivers and scenarios, and applies modelling approaches to generate insights and inform future strategy and policy decisions. The challenge is to be able to model how urban system design could respond to the local climate and tweak this design to achieve climate resilience with minimum costs.

The Analytics and Decision Sciences program develops bespoke tools, platforms and models to gather big data analytics, spatio-temporal analytics, risk analytics, multimedia analytics and private data analytics. CSIRO transforms this data into insights through numerical modelling, quantitative risk and visualisation technologies. CSIRO's Data61 also applies operations research, natural data science, artificial intelligence and even computational linguistics to show the environmental innovation opportunities through analysis and predictions [9].

(3) Capabilities and Methodology

In terms of capability, following techniques and specific processes are applied at CSIRO:

- Spatial imaging technology, including platform development and machine learning for large scale spatial inference
- Sensing and data acquisition, data analytics tools
- Machine learning, modelling and optimisation to make predictions and optimise services
- Simulation and analysis of bushfires and floods to help mitigate environmental issues and disasters
- Privacy preserving technologies to allow insights to be gained from data sets while protecting information about groups or individuals
- Automated compliance - using machine learning and natural language processing to check digitised rules and obligations

Australia's climate varies significantly across the country, and even within individual states. Urban service system, houses, transport, building and infrastructure need to be designed to adapt to their unique environment. Specifically, **CSIRO's** research methodology consists of:

-Quantifying current and future climate hazards, especially extreme events

-Assessing the risks posed to communities and businesses, and prepare risk mitigation options for extreme events, such as coastal inundation due to sea level rise and storm surge, more frequent or severe storms, cyclones, hail events and floods

-Quantifying the role of urban development in creating liveable urban and building environment under changing climate, and prepare options to reduce impacts on public health, such as green infrastructure

-Achieving co-benefit of energy efficiency/greenhouse gas emissions reduction and resilience to accommodate the changing climate for homes, buildings and transport

-Developing tools for communities and businesses to establish adaptation capacity with enhanced knowledge and preparedness in response to the changing climate.

A typical process for flood modeling as an aspect of climate impact is dsiplayed in Fig.16 [9].

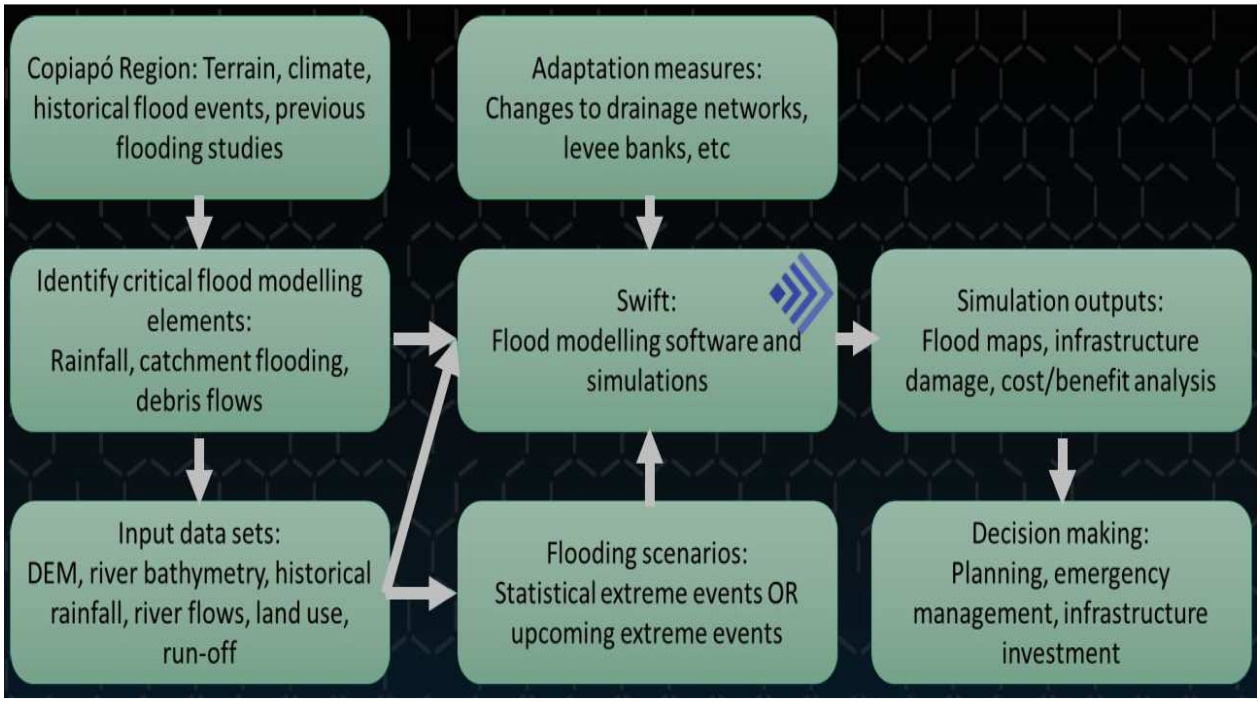

Fig.16 Flood Modeling Process

CSIRO works with the Australian Bureau of Meteorology to produce the most comprehensive set of climate change projections for Australia ever released. Natural disasters predictions for policy makers are shown in Fig.17. The projections are based on data from up to 40 global climate models, developed by institutions around the world, that were driven by four greenhouse gas and aerosol emissions scenarios. Results have been prepared for 21 climate variables (both on the land and in the ocean) and for four 20-year time periods (centred on 2030, 2050, 2070 and 2090). CSIRO's scientists also use results from climate models that are based on established laws of physics. Confidence ratings for the projections are based on following lines of evidence [9].

-Model reliability at simulating the past climate

-Consistency between models regarding the projected magnitude and direction of change

-Results from relevant downscaled projections

-Evidence for plausible processes driving the simulated changes, and

-The level of consistency with trends in the observations.

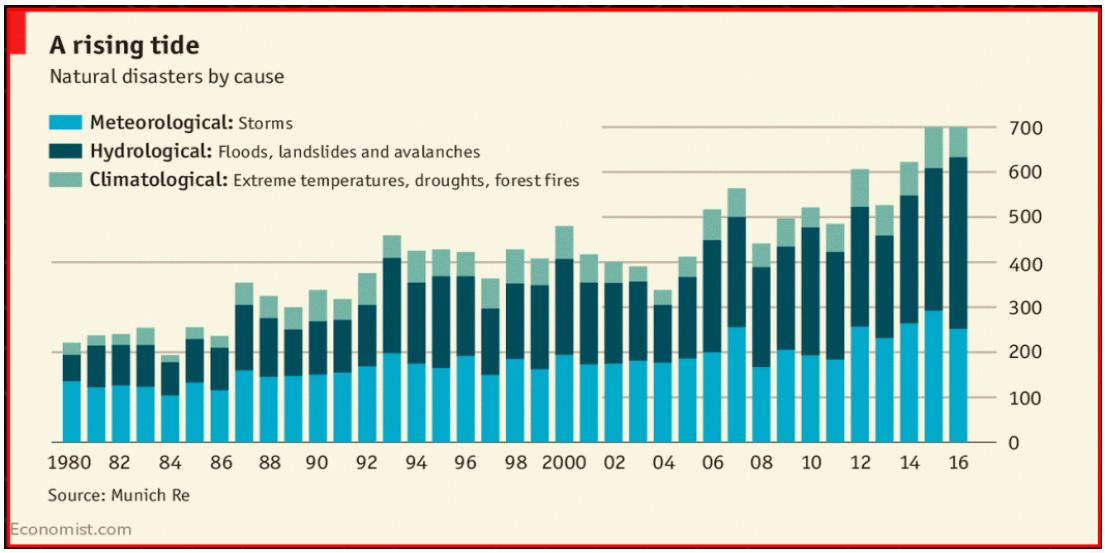

Fig.17 Natural Disasters Predictions Associated with Diverse Causes

The projections draw on the full breadth of available data and peer-reviewed literature to provide a robust and innovative assessment of the potential future climate. A key innovation in the methodology is the use of AccuRate model for building environmental resilience modelling. AccuRate can model up to 50 living spaces and 99 zones within a home; a significant increase from the earlier modelling software. The model includes a wide range of factors that impact a house's energy efficiency; such as natural ventilation, insulation, air leakage, thermal mass, roof spaces, sub-floor spaces, skylights, horizontal reflective air gaps, windows, and external shading structures such as neighbouring buildings, trees and fences. AccuRate allows designers to flip and rotate buildings, which is particularly useful in assessing the energy efficiency of apartment complexes or large housing projects. It also includes extra modules that allow designers to investigate other sustainability parameters outside the energy efficiency rating, like lighting, space heating and cooling, hot water, water usage, and embodied carbon dioxide [9].

The multiple and interconnected challenges are expected to intensify over the remainder of this century, requiring a radical re-think of how cities are planned, designed and managed in Australia. Long-established trends, complacency and risk aversion act to constrain urban environmental innovation. The specific fields of urban sustainability research outcome are summarized in Fig.18 below.

Fig.18 CSIRO's Urban System Sustainability Research Outcome

3.6 Learning from France: Digitalization for Environmental Innovation, Veolia Group

Veolia group is the global leader in optimized resource management. With over 171,000 employees worldwide, the Group designs and provides water, waste and energy management solutions which contribute to the sustainable development of communities and industries. Through its three complementary business activities, Veolia helps to develop access to resources, preserve available resources, and to replenish them. Veolia is engaged to contribute to reduce the environmental footprint of cities, make them more attractive, preserve the urban quality life, and provide efficient public services.

Smart environmental utility is now a priority for many municipalities. It helps to redesign the way urban spaces are used and brings together all the city stakeholders around a more open and integrated model of governance. Veolia has thus developed with big data, smart solutions capable of improving waste flow control and recovery, water treatment, energy management and empowering citizens and businesses to strengthen resource recovery [8].

(1) Big Data for Innovative Water Resource Management System

Water industry is facing numerous challenges such as aging infrastructure significantly increasing the risks of failure/crisis, maintenance costs, and the need for large investments to renew assets. The levels of legal constraints and reporting requirements are constantly increasing, and the water utilities continue to face the impact of climate change, especially increasing risks of drought and water scarcity. On the other hand, the water utilities are increasingly required to meet greenhouse gas emission reductions set by governments.

Waternamics has been developed by Veolia to integrate all data sources collected at water utilities in the same platform, and enhance 'situational awareness' of network and operations. Waternamics is based on IBM's integrated operations and analytics platform, and has been adapted by Veolia to address the needs of water operators worldwide. Waternamics is composed of a base platform allowing visualisation of integrated data and automation of standard operating procedures. Additional modules offer more advanced and specialised functionalities to ease operations for the entire water cycle such as [8]:

- Drinking water network module - identifying sections of the network with high potential of failure to design a prioritised pipe renewal program
- Wastewater network module - assisting water utilities in operating wastewater treatment plants, identifying surrounding areas affected by wastewater odours and detecting emerging pollutants in wastewater
- Water resources management module - optimising the management of water resources to minimise risks of water scarcity and treatment costs
- Energy management module - identifying energy management issues in the entire water cycle in order to optimise energy procurement contracts and minimise energy costs
- Wastewater treatment module - detecting inflows and infiltrations, optimising the management of network storages to minimise overflows and prioritise asset renewal.

Supporting a population of 1.3 million people, Lyon (France) required a smart water solution that included online sensors on the drinking water network and a platform integrating data from internal and external systems. Waternamics has played a major role in this success. The city was facing the following challenges including aging infrastructure - approximately 400 leaks per year; heterogeneous water demand - while the water demand was decreasing in the South East districts of Lyon, the water demand increased in central areas; increasing customer expectations; climate change - the increasing occurrence of freezing episodes and the increase of associated risks of blowing pipes; emerging chemical pollutants - the Rhone River (one of the main sources of drinking water in the area) was no longer considered as a sustainable water source [8].

Together with the implementation of thousands of sensors (including acoustic leakage sensors, water quality sensors, digital meters, etc.), Veolia has dramatically increased the performance of the network, improved the efficiency of the field teams, and has successfully upgraded service levels to customers. In Australia, Veolia is even currently trailing the solution with a Victorian water authority and is due to be implemented Waternamics in a phased approach across the state. The water management system is illustrated by the Fig.19 [8].

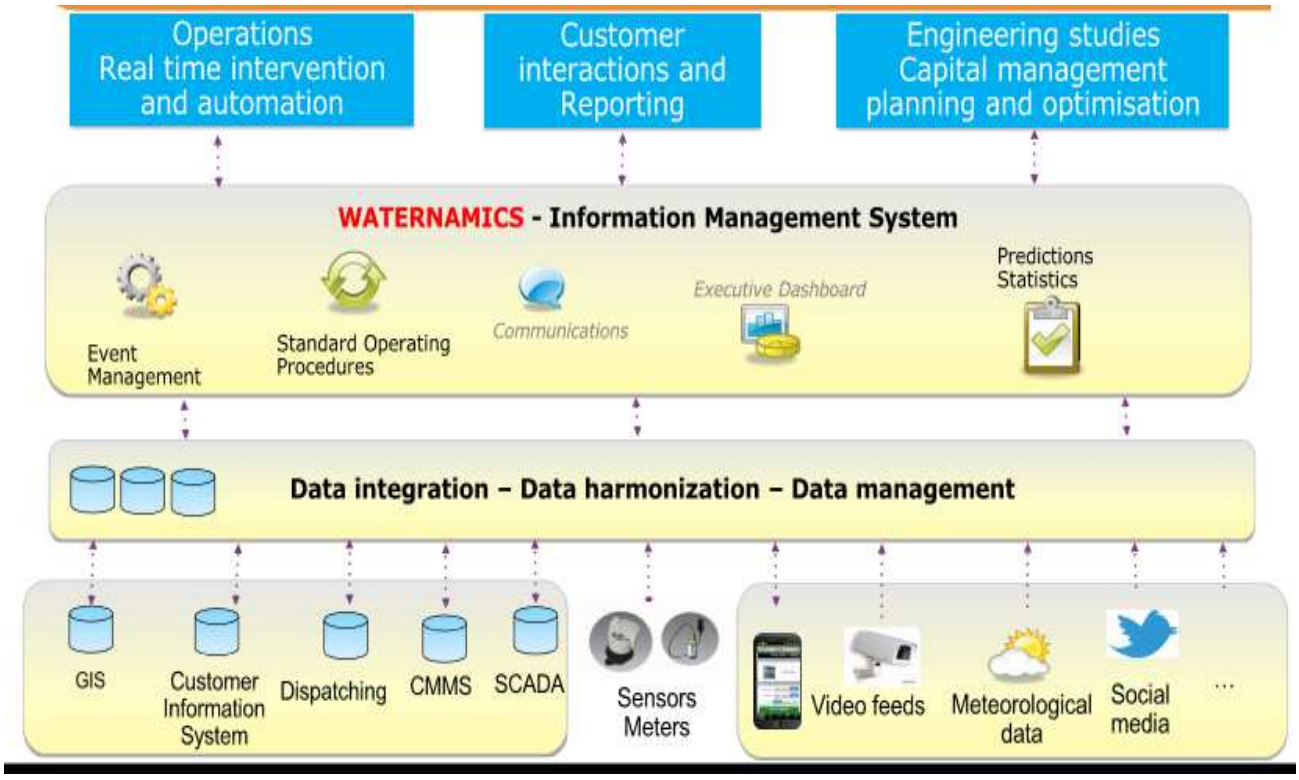

Fig 19 Digitalized Water Management System

(2) Innovative Waste Management System

Big data provides smart cities with information on the waste flows and pollution that cross them in real time for better management and recovery. Big data can help to optimize the management of resources, waste, and pollution in real time, and can be an accelerator for the circular economy. Veolia has developed mobile applications to help citizens make circular choices about how to manage their waste such as *Urban Pulse*, that references, among other things, all recycling centers, voluntary waste drop-off receptacles, second-hand and repair stores, and the *Too Good to Go* application, which allows retailers and restaurant owners to propose products and meals at reduced cost because they were going to be thrown away. Waste containers are equipped with sensors to send information to collectors on their weight, fill level, and composition (organic materials, metals, textiles, etc.) to optimize sorting and thus repair, reuse or recycling (Fig.20).

Based on big data, Veolia offers multiple collection systems adapted to the territorial and economic stakes of its customers. Waste of the same nature is gathered in collection centers where it is compressed before being sent to an appropriate sorting or treatment site. Veolia transports solid waste to specialized sorting centers. Many patented processes, such as auto-adaptive sequential sorting, are used to achieve recovery rates of up to 95 %. The recovered waste then becomes secondary raw materials for industry. Veolia also recycles complex waste, such as batteries and electronic cards [8].

Non-recyclable non-hazardous waste is transported to incineration plants or landfills. The incineration process produces energy in the form of steam which can either supply district or industrial heating networks, or be converted into electricity using turbines. The electricity generated is used to power the national distribution network. Veolia captures the gas generated by the fermentation of organic waste in its landfills. This biogas can be directly delivered to a distribution network, used to produce electricity through turbines or engines, or used as fuel for vehicles. Veolia operates 63 household waste incineration plants and 53 non-hazardous waste landfills equipped with biogas recovery systems.

Sewage sludge, green waste and organic waste from households or the catering industry, the food processing industry or the agricultural sector are recovered by subsidiaries specialized in the treatment of organic waste. Treatment is either achieved through controlled composting or anaerobic digestion in biogas plants. The compost produced is used as fertilizer for agriculture and the methane generated by fermentation is recovered using the same procedures as those for landfill biogas. Veolia operates 104 composting platforms and 7 biogas plants [8].

Fig.20 Smart Waste Management System

(3) Innovative Pollution Abatement

One of the major problems facing cities today is traffic congestion and consequently the emission of large amount of heavy air pollutants and CO_2 (Fig21). Based on big data, Veolia offers the possibility of reducing urban pollution by rethinking the use of transportation in favour of soft mobility. Logistic chains are increasingly greener with big data. With the digitalization, companies have all the information about their stocks and deliveries made at their fingertips: customer availabilities, routes, weather conditions, road traffic, etc. Such digitalization allows stakeholders to adjust their flows in real time and organize their deliveries more efficiently with less pollution.

Eco-mobility solutions are also developing to allow residents to travel while minimizing greenhouse gas emissions as far as possible, such as Blablacar, the famous car-pooling service, Drivy, which allows individuals to rent their vehicles to each other, and ZenPark, the application dedicated to shared car parks.

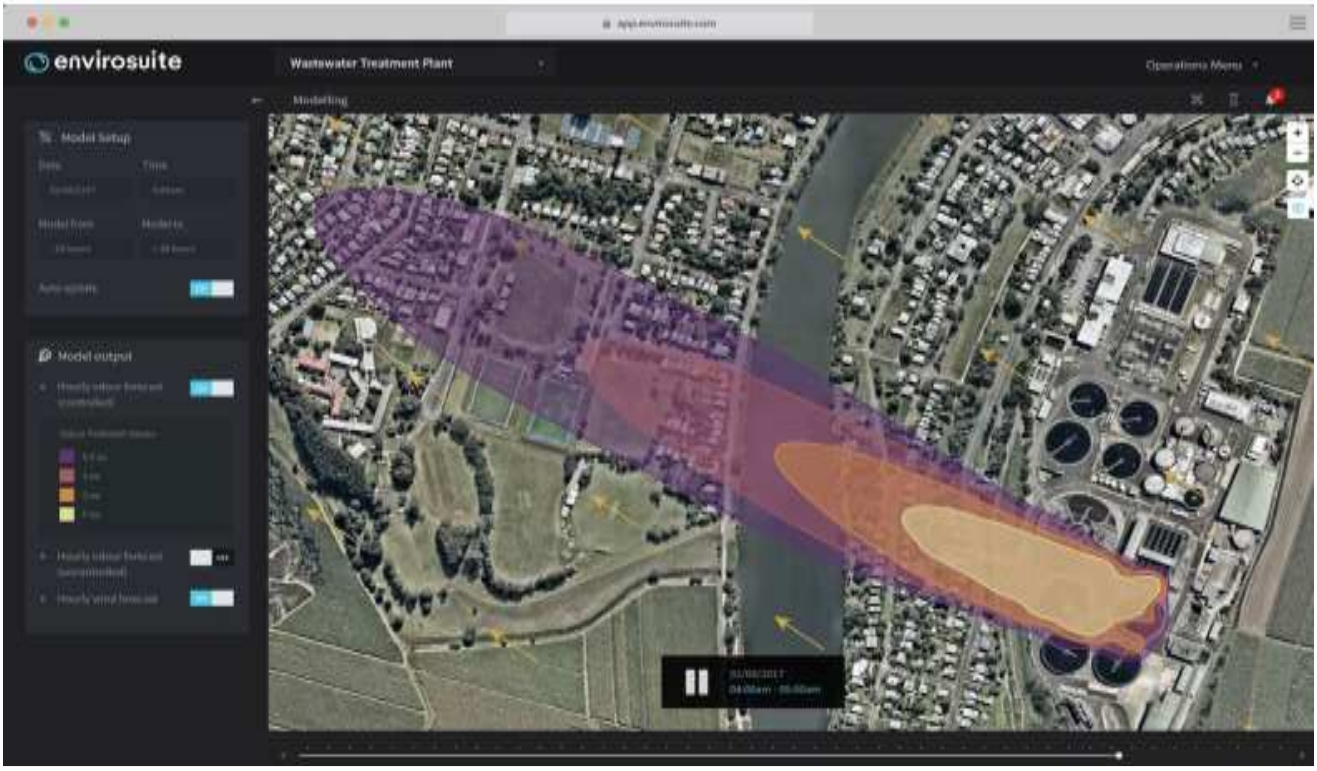

Fig 21 Smart Air Quality Assessment

(4) Digitalized Energy Management

The emergence of smart grids provides Veolia with an opportunity to use big data for enhanced efficient electricity distribution and promotion for efficiency energy. Smart grids use connected sensors to take the needs of consumers at different points on the network into account in real time. This allows consumers to continuously balance supply and demand as well as optimize energy production and storage upstream. The Veolia Group helps cities define a low-carbon energy strategy by developing an energy mix that privileges the use of renewable and alternative energy sources: geothermy, biomass, co-generation or recovery of heat generated by the incineration of household waste, wastewater plants, etc.

Veolia has also developed digitalized energy services to reduce the energy consumption and CO_2 emissions of buildings while preserving the comfort of their occupants. Based on big data, the Group developed an improvement plan including the installation of enhanced energy-efficient equipment, tools for monitoring consumption and managing performance, as well as devices encouraging occupants to save energy. Hubgrade is a hypervision system for building and infrastructure energy efficiency monitoring service developed by Veolia. Designed as a truly integrated management platform, Hubgrade collects data in real time which is analysed by the Group's experts to optimize the energy usage. This tool allows potentially higher energy savings in buildings in comparison to other energy efficiency services on the market. Veolia currently manages 9 Hubgrade centers worldwide [8].

Veolia's energy solutions meet the reliability, quality, availability and cost requirements of industrial customers for which energy is a key competitiveness issue. The Group optimizes industrial utilities, regardless of their nature (steam generation, cooling, electricity, compressed air), as well as energy use related to processes and industrial buildings. This allows Veolia to help secure supply for its customers and reduce their energy and carbon footprint. In France, the GreenLys project successfully tested the smart grids principle with 1,000 customers and forty companies in Lyon and Grenoble for four years. The experiment was based on the use of Linky, a smart meter that will be deployed throughout the entire French electricity network by 2021. A summary of Veolia's digital system is provided in Fig 22 [8].

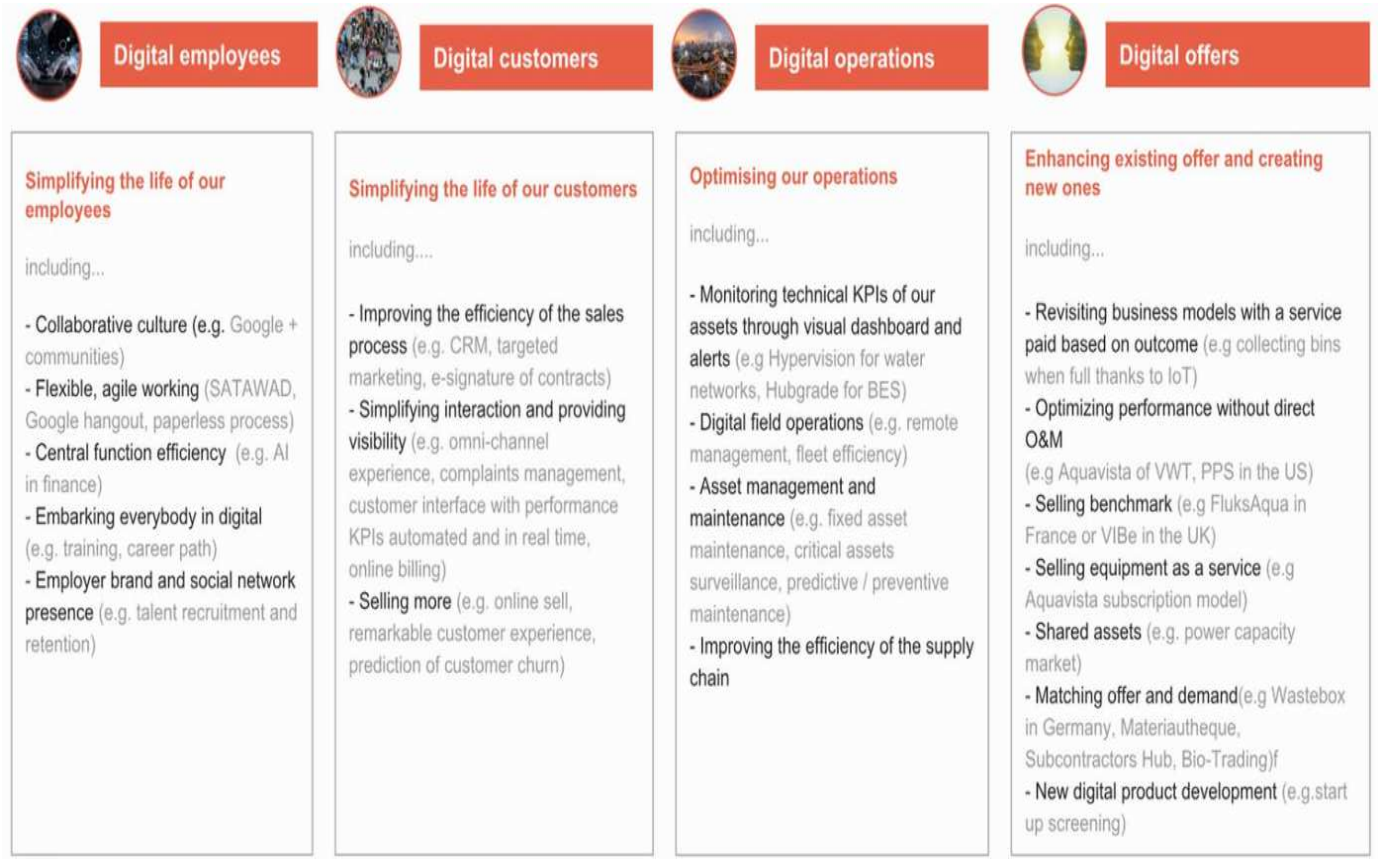

Fig.22 Veolia's Digital Journey

3.7 Experience from Schneider Electric: Digital Transformation for Innovation & Sustainability

As the global specialist in energy management and automation, Schneider Electric is committed to worldwide improvement in connectivity, sustainability, efficiency, and reliability and safety in five primary areas including homes, cities, industries, buildings and cloud through the ''Internet of Things'' revolution [1].

(1) Practical Implications of the ''Internet of Things''

The recent growth of Internet-connected industrial and personal devices has been referred to as the 'Internet of Things' (IoT) revolution. In fact, this trend is really an evolution that has been underway for quite some time. The key drivers which have accelerated the trend include a broader adherence to open standards (such as Ethernet) and technology breakthroughs in the area of data aggregation middleware. This provides new opportunities to drive business in a much more efficient manner (Fig.23). At Schneider Electric, the expertise has always been in facilitating increased business efficiencies, particularly in the areas of IoT-driven operational intelligence, energy management, and automation [1].

Today, Schneider Electric is helping to drive Industry 4.0 smart manufacturing standards. The desire to measure and compare the effectiveness of objects that humans interact with is leading to a rapid acceleration in data creation, and more visibility to that data. For instance, a plant manager today has access to 10 times more information about his plant than he did 20 years ago. In addition, plant/shop operators now have access to data from other off- the-shop-floor systems. For example weather data can be used to predict crop growth, which can then be used to predict the need for fertiliser manufacturing over the upcoming three months. The fertiliser production plan therefore becomes more accurate. IoT allows plants to now monitor new variables that, in the past, were cost prohibitive [1].

Measurement of vibration on machinery and power consumption on all branches of the power system are some examples of how IoT can be cost effectively leveraged. These lower entry costs are leading to the explosion of new data - adding a more granular level of data on the existing assets. The free-flowing yet structured management of the new data allows stakeholders within organisations to improve real-time energy and automation tracking in order to cut costs, and operate more safety, reliably, and efficiently. It also helps operators across the globe respond to rapid changes in market demand in inventive ways. Outside of industry and business, consumers all over the globe are also interacting with sensors that communicate data. The five core IoT-driven competencies include the following [1]:

- Business process efficiency (higher productivity and profitability)
- High asset availability and performance (predictive and condition based maintenance)
- Risk mitigation and safety (embedding safety into our product designs)
- Enablement of faster time-to-market (securing both centralised and edge applications)
- Sustainable growth (low CO_2 emissions products and systems).

Schneider Electric delivers solutions at each architectural layer: the core of connected field devices (sensors, drives, meters, PLCs, controls, switchgear), the platform layer (cloud services, middleware, physical infrastructure architectures), and the on-premise central control layer (remote monitoring, predictive analysis, simulation, cloud analytics, etc.). All of these elements are designed within a balanced envelope of security (physical security and cyber security), and open protocols/open connectivity. These Schneider Electric IoT competencies have been developed over time as a result of millions of dollars invested in research and development and innovation.

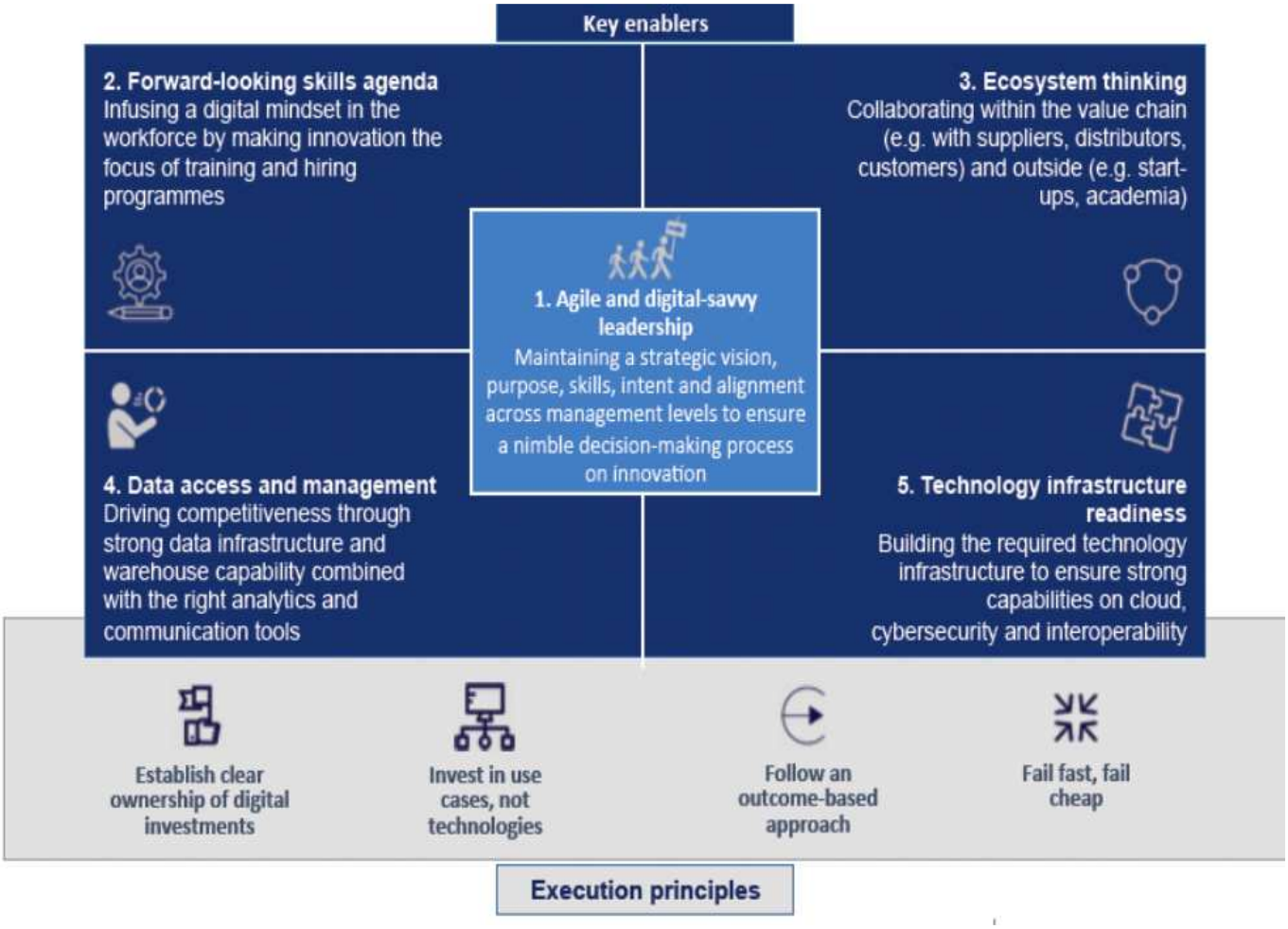

Fig.23 Key Enablers of the Digital Revolution at Schneider Electric

(2) IoT Environments

On a global front, IoT technologies are driving new business models that facilitate a service-oriented culture, and new revenue streams are being created (such as the growth of 'prosumers', individuals or organisations that are rewarded by utilities for their adherence to load-shifting requests). Leading analysts such as McKinsey & Company ArcFM GIS A powerful extension of ESRI's ArcGIS® platform, Schneider Electric ArcFM Enterprise GIS provides a graphical, data-rich environment, displaying the information utilities need for maximum reliability and efficiency. Developed as a complete enterprise solution for an entire organization, ArcFM GIS offers a map-centric, intuitive way to model, design, maintain and manage facility, and land based information. Because geographical information is built into the map data, the asset changes and updates are more apt to operate appropriately under the conditions in the geography, reducing the chance of outages and increasing reliability for the customers. ArcFM GIS is just one component in the Smart Grid Solutions Suite, a comprehensive toolset created to help stakeholders efficiently plan, design and reliably operate the grid [1].

With capabilities that include data collection and monitoring, grid analytics, rules-based economic decision making tools, and the ability to integrate with traditional business software, the Schneider Electric Smart Grid Solutions Suite can help the utility transition into a next-generation energy provider. IoT enables higher levels of collaboration, changes the way goods are produced, and influences the way of mobility, work, and convalesce at hospitals.

(3) IoT as Potential Driver of Sustainability

Corporate sustainability programs of the past were rarely successful due to difficulties in implementation and measurement. Schneider Electric's IoT capabilities have helped to change all of that. By establishing robust smart monitoring of water and electricity assets, a baseline can be established to track how these resources are consumed. Sustainability plans can now be built on accurate consumption data so that measureable improvements can be executed. As machine-to-machine, machine-to-people, and people-to-people interactions occur with more frequency, tools need to evolve that help all participants make sense and good use of this avalanche of data. Schneider Electric has the tools and expertise in place to assure that "Life is On!" for customers and partners across the globe. Schneider Electric now has the technologies and expertise in place to realise its shared goals of growth in innovation, better operational performance, improved safety and security, and reduced environmental impact (Fig.24).

BENEFIT	UP TO	AVERAGE
CapEx		
Engineering costs and time optimization	80%	35%
Commissioning costs and time optimization	60%	29%
Investment costs optimization	50%	23%
OpEx		
Energy consumption savings	85%	24%
Energy costs savings	80%	28%
Productivity	50%	24%
Equipment availability and uptime	50%	22%
Maintenance costs optimization	75%	28%
Sustainability, Speed, and Performance		
CO_2 footprint optimization	50%	20%
Time to market optimization	20%	11%
Decrease in occupant comfort-related incidents	33%	24%
Return on investment	0.75 year	5.3 years

Fig.24 Power of Digital Transformation at Schneider Electric

(4) Smart Building Management Innovation

From design, through integration to commissioning, Schneider has developed EcoStruxure building based on IoT that brings best-in-class engineering efficiency to buildings (Fig 25). Combined with the asset and energy performance services, Schneider enables lifetime efficiency of your building ensuring productivity and comfort for occupants.

Building management is getting easier and more powerful thanks to innovative technologies. Learn how connecting devices with software and services makes today's buildings and their occupants work smarter and more efficiently.

In today's digital world, power distribution in buildings is undergoing a fundamental and irreversible change. EcoStruxure building enables improved day-to-day operations, allowing you to track energy use and potential for energy savings [1].

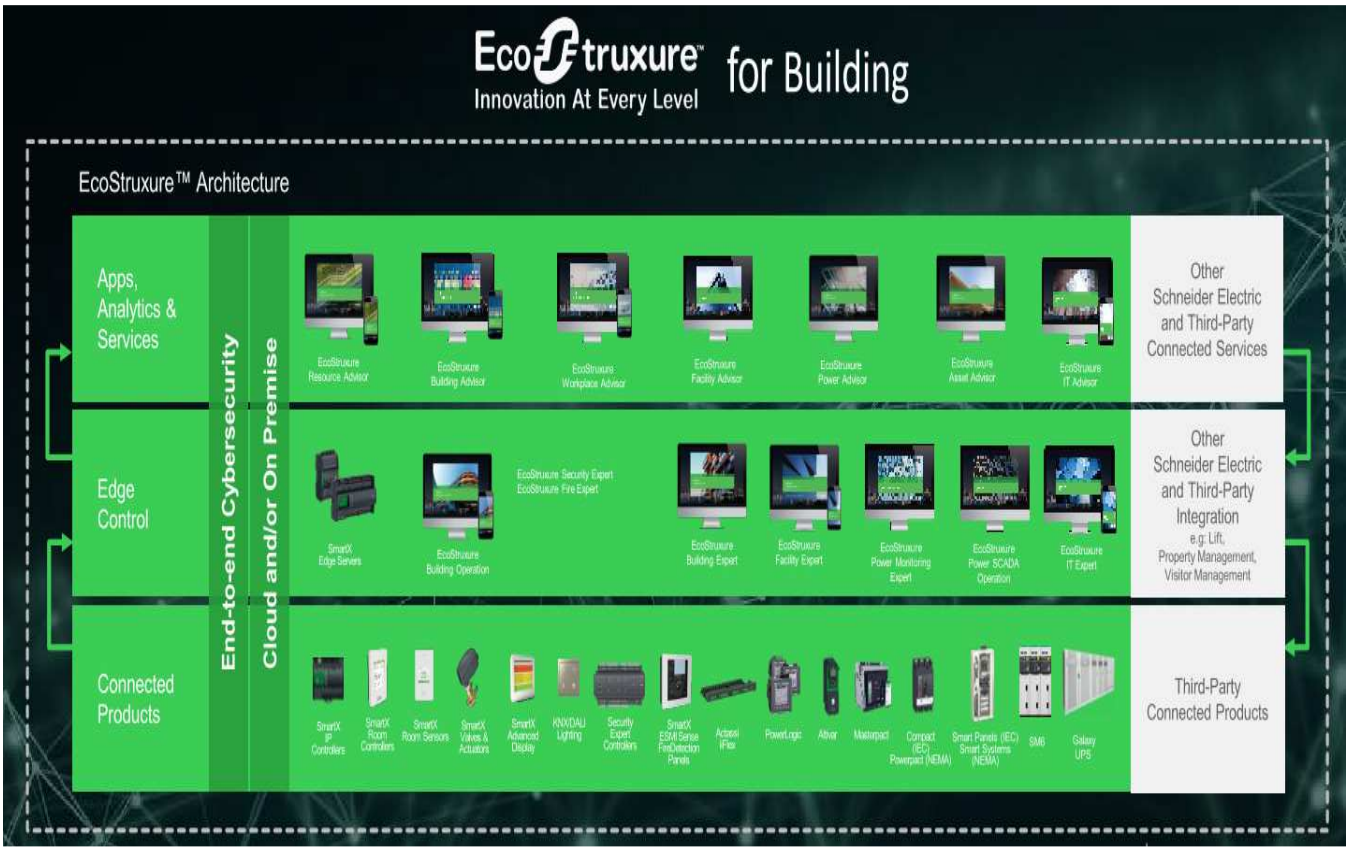

Fig.25 Smart Building Management at Schneider Electric

(5) Innovative Water and Wastewater Management

More stringent water quality standards force Water & Wastewater companies to invest in new treatment technologies and processes. Water & Wastewater companies need to invest constantly to replace pipes, refurbish and expand their treatment plants. Water & Wastewater plants need to reduce operating costs while facing less capital available to invest in new infrastructure or renew older plants. Weather-driven events are threatening the resilience and capacity of Water & Wastewater infrastructure. The new generation of personnel has created the need for predictive analysis and decision support systems in order to operate and maintain the Water & Wastewater infrastructure [1].

Advanced water utilities monitor their distribution networks acquiring data from network critical points (ie. production and storage points, inlets of distribution zone, etc.), and making them available in real time to operators in a centralised SCADA control room. The Water Network Optimisation solution enables operations managers and control room operators to manage their network in a more informed manner by [1]:

-Incorporating virtual sensors apprising operators of hydraulic and water quality parameters at any point of the distribution network, thus enhancing real-time supervision in SCADA.

-Evaluating the evolution of water network behaviour, and identifying potential issues regarding levels of service breaches (in terms of pressure, water quality, etc.) over the next hours and days.

-Analysing the results of an alternative what-if scenario and comparing it with the business-as-usual scenario -without having to rely on hydraulic simulations run from other departments.

-Analysing a complete set of key performance indicators (KPIs) on energy usage, network pressure conditions, and water quality.

With a vast water distribution network (Fig.26), it is imperative for water utilities to have an overview of their entire network in real time and in "future time." Water Network Optimisation is able to trigger alarms associated to potential anomalies detected by simulations. This enables operators to be warned of current critical situations in the network so that immediate actions to prevent or mitigate service disruptions can be taken with enough lead time. The digital transformation also enables:

-Quicker and improved operational awareness, including early warning on deviations from expected levels of service

-Transformation of a network management approach from reactive to proactive to events, with better operation and maintenance planning for risk reduction

-Prioritisation of intervention on network and pumping stations

-Improved control room user experience with visualisation of contextualised operational data and enhanced alert management within an operator-friendly SCADA environment, without having to switch between applications.

Fig.26 Smart Water Management Innovation at Schneider Electric

4-Business Opportunities & Competitiveness of Green Innovation

4.1 Development of Radiant Ceiling Plus Fresh Air System (RCF)

(1) Company Profile

Elevating Hong Kong into a regional hub for innovation and technology development has been the vision since our inception in 2002 during its foundation. Throughout the years, the company has cultivated a fertile ground for innovation and technology ecosystem. The company channels supportive initiatives and resources to five major technologies clusters including biomedical technology, electronics, green technology, information and communication technology, material and precision engineering. The technology clusters contribute to devising innovative solutions for three platforms in focus smart city, healthy ageing and robotics [13].

(2) Characteristics of Radiant Ceiling Plus Fresh Air System (RCF)

In accordance to its innovation vision, and in line with the promotion worldwide of carbon-neutral technology development, AirStar Air Conditioning Technology Group (HK) Ltd has developed the "Radiation ceiling plus fresh air technology (RCF)" which was granted patents in mainland China, Hong Kong, Singapore, Japan, Australia and the European Union. RCF technology (Fig.27) is capable of saving at least 40% energy with 60% maintenance cost reduction, while attaining better comfort level (based on the ASHRAE 55-2010 standard) compared with traditional air-conditioning systems [13].

AirStar is confident that its unique technology is on track to eventually dominate the world market, and revolutionize not just environmental conservation but also health. It is ideal for deployment in high density buildings where reduction or elimination of cross infection (especially in a pandemic scenario) is a top priority. In addition to hospitals, the RCF technology can be applied to airports, subway transport, hospitals, hotels, schools, office buildings, electronic factories and many other sites in the world.

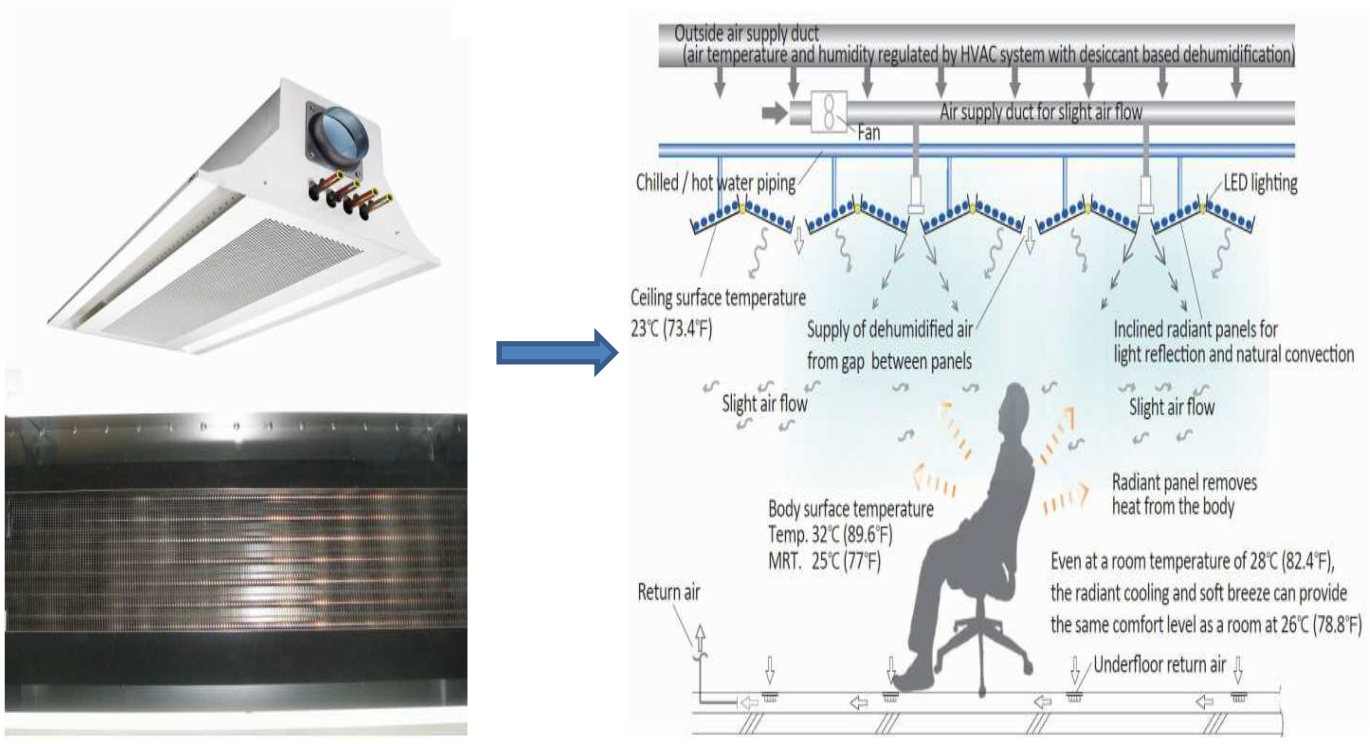

Fig.27 Radiant Ceiling Plus Fresh Air System (RCF)

(3) Potential Outcome of the RCF Technology

The RCF uses 7°C traditional chilled water and solves the drawback of condensation and low radiation abilities of the European technology. Only 40% ceiling coverage plus code required fresh air to guarantee the healthy IAQ on better comfort level, CO_2 content and RH whereas saving installation and operating load by at least 40% compared to conventional air conditioning system with a sensation temperature of 24℃.

On the other hand, RCF technology can reduce the space requirement by 400 mm compared to VAV system, save 50% of AHU room area, and contribute to LEED certification by more than 20 credits. Other potential advantages of the RCF are listed below [13]:

•Quiet as there is no fan motor and air sound

•No condensation at panel surface

•System can be designed in both cooling and heating mode

•Better regulate human comfort level through the thermal radiation

•Advance indoor air quality by deeply dehumidified fresh air and discharge of CO_2

•Energy expense hugely vary for different heat transfer methods

•Cooling equipment start-up capacity and regulating ability for partial load are particularly vital

•Uniform panel surface temperature

•Higher radiative intensity

•Effective air treatment by PAU with super dehumidification capacity

•Unique and intelligent control logic

•Entirely solve the condensation problem in cold operation mode

•Designed on remote monitoring and operating system

•Excellent IAQ

•No air draught feeling

•Save ceiling void at least 0.3M compared to VAV

•No need for setting chiller plant rooms on the upper level of the high-rise building

•Prevent cross-infection due to no air re-circulation

4.2 Eco-innovation of Lithium-ion Battery Manufacturing and Recycling

(1) Company Profile

Green Renewable Sustainable Technology **(**GRST) is a Hong Kong based-technology company, which holds interest in the development of green and sustainable energy storage. From breakthrough Water-based Manufacturing to Recycle, Regenerate and Reuse (WATMAR) process to Super-safe Technology for lithium ion battery, the company offers its customers complete energy storage solutions to meet there specific application needs [10].

GRST aims to provide a platform for the continuous expansion of green technologies in industry, always thrive to improve safety and performance, promote a sustainable circular economy to the market, utilize competitive strengths of water-based battery manufacturing and recycling technology to promote green technology development and conduct market-driven and demand-led product development that is low carbon and resource efficient. Basically, GRST always puts sustainability, reliability and performance as our top priority in our business. The company provides total solutions for:

-The production of a green and high-performance lithium-ion battery with competitive costing

-The development of reliable battery energy storage systems for the rapidly changing electromotive, industrial, consumer electronics, and renewable energy storage markets.

GRST has more than 100 patents/patent applications across various fields including battery production, recycling, safety and application - fled in US, EU, China, Taiwan, PCT. Most of the core patents have been granted [10].

(2) Innovative Green Manufacturing of Battery

As described in Fig.28 below, green manufacturing of lithium-ion batteries creates a sustainable recycling circular economy which helps to gradually decrease dependence on imported raw materials, suppress price fluctuations of raw materials, and secure the supply of strategic resources. GRST has also patented disruptive core technologies that ensure cleaner and greener manufacturing and recycling of lithium-ion batteries [10].

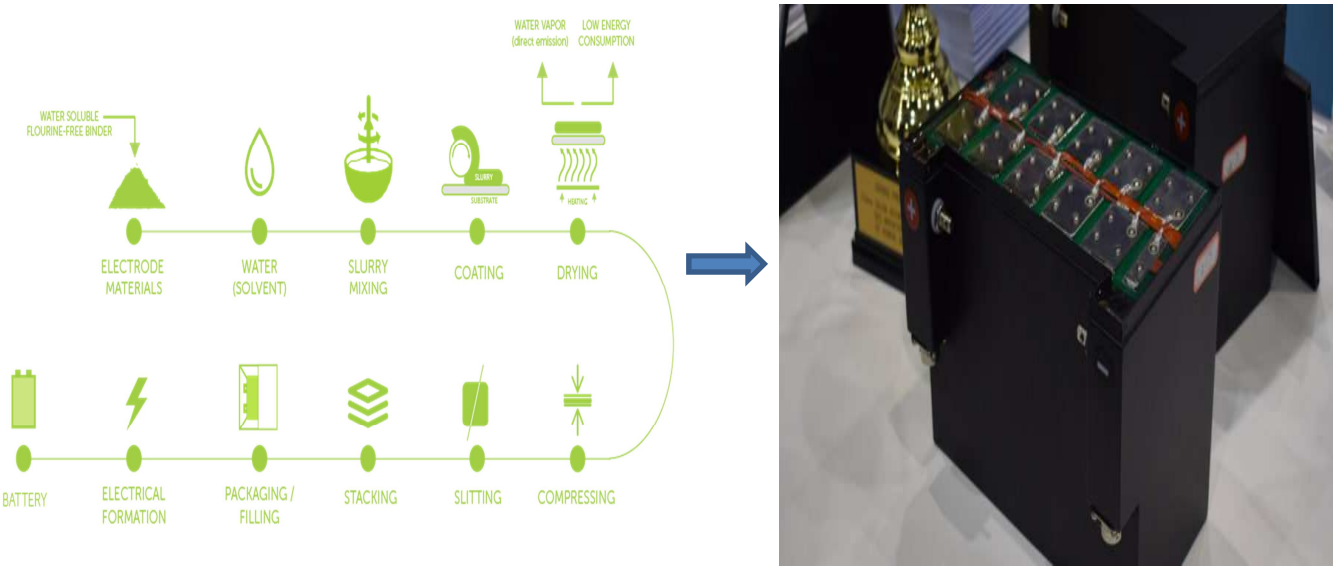

Fig.28 Lithium-ion Battery Green Manufacturing Process

(3) Safety

Safety is a key consideration for the GRST lithium-ion battery. As such, through material and structural design, the battery safety has been significantly improved. The safety performance of GRST lithium-ion battery is outstanding in both the nail penetration and overcharging tests. For mining applications, GRST further improves battery safety through advanced material technology. GRST battery can be charged / discharged over large temperature range [10].

(3) Battery Lifepan

GRST battery life expectancy has a range of >5000 cycles depending on applications described as follows:

•Energy Storage System (eSS), >5000 cycles with >80% capacity retention

•Electric vehicles (ev), >3000 cycles with >80% capacity retention

•Consumer electronics and power tools, 1000-1500 cycles with >80% capacity retention

(4) Green Recycling System

The proprietary water based lithium battery manufacturing process leads to simple recycling, generation and reuse. The green recycling process (Fig.29) accounts for revenue boosting, high recovery rate, low energy consumption, closed-loop process, green and sustainable treatment.

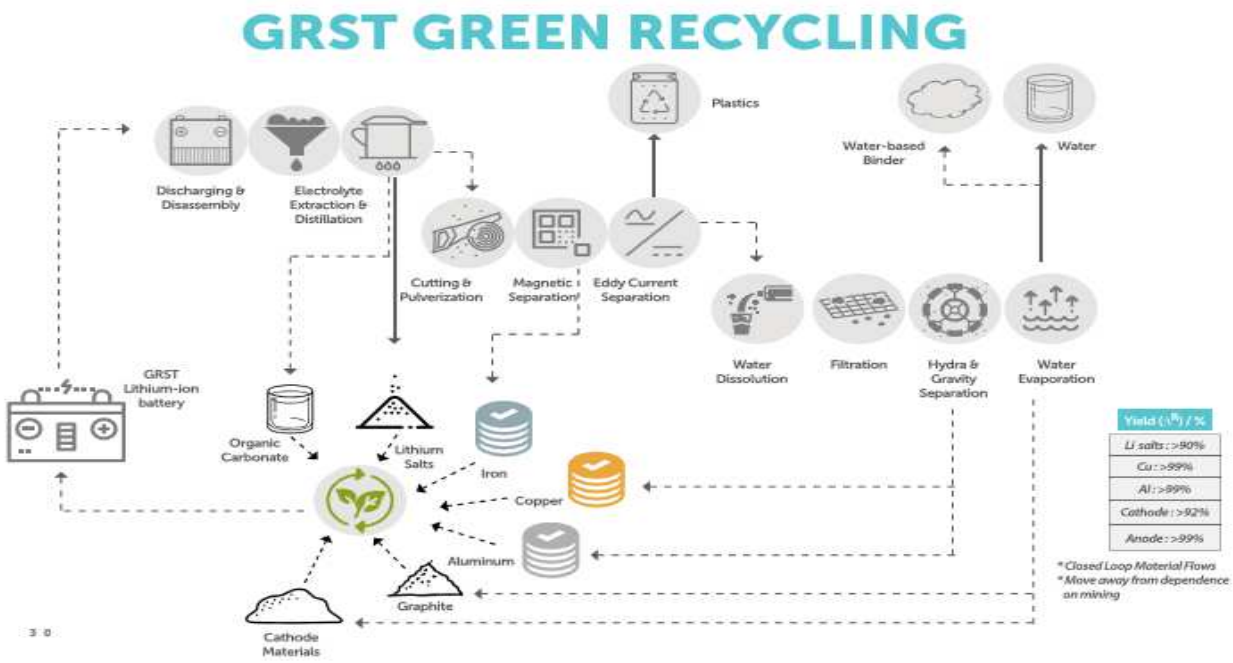

Fig.29 GRST lithium-ion battery Green Recycling Process

(5) Comparative Advantages of GRST Battery

GRST Battery is a completely ecological lithium-ion battery, which generates no pollutants in the production process, and which is totally recyclable in every part. Such a novelty will certainly revolutionize the world of portable devices. Key advantages of the battery are described below:

-Potential CO_2 emission saving

-Uses only water and water-based binder (NMP-free)

-Potential saving in capital cost: no expensive solvent recovery system or large-scale dry room necessary

-Creates better manufacturing environment for workers to combat the adverse health effects of using NMP and PVDF

Detailed description of the comparative advantages of GRST Battery with the conventional manufacturing is displayed in Fig.30 [10].

	CONVENTIONAL CELL MANUFACTURING	GRST CELL MANUFACTURING
CAPITAL EXPENDITURE	**HIGH** A. Large-scale dry room & humidity-controlled environment (20-40% of total factory space) B. NMP solvent recovery system needed	**LOW** A. Small-scale dry room & humidity-controlled environment only (<5% of total factory space). B. No NMP solvent recovery system needed
ENERGY CONSUMPTION	**HIGH** A. High operating temp. (>90°C) for electrolyte drying B.Large humidity controlled systems C.NMP solvent recovery systems	**LOW** A. Low operating temp. (40-60°C) for electrolyte drying B.Small humidity controlled systems C.No NMP solvent recovery systems needed
ORGANIC SOLVENT NMP / FLUOROPOLYMER PVDF	**YES**	**NO**

Fig.30 Comparative Advantages of GRST Battery with the Conventional Manufacturing

4.3 AI and Big Data Analytics for Smart City Infrastructure and Environmental Management

(1) Company Profile

Founded in 2000, ClusterTech Limited is committed to providing value to clients through advanced computing technologies including Cloud, High Performance Computing, AI & Analytics and Big Data. ClusterTech Limited provides a comprehensive range of services and products to solve problems in massive data processing, large-scale computing, in-depth analysis, artificial intelligence, and uninterrupted service. The company business areas include financial engineering (investment analysis, risk management, derivatives pricing, etc.), business intelligence (sales forecasting, customer management, inventory management, etc.), environmental science (weather forecast, heavy rain and turbulence forecasting, analysis and prediction of pollution, etc.), smart city (information gathering, information analysis, optimisation and management), and internet applications (massive image processing, video storage and delivery). The company also provides public cloud, private cloud and hybrid cloud solutions for businesses of all sizes [6].

ClusterTech has enjoyed years of steady growth, extending its business from its Hong Kong headquarters to Mainland China, Taiwan, UK, Canada, Australia and Singapore, and provided modern computing products and services to hundreds of national and international institutes and companies (refer to our customer list). ClusterTech has branch or representative offices in Sydney, Australia, Beijing, Shanghai, Xi'an, Guangzhou and Shenzhen to provide local support to clients. Group members of ClusterTech

include ClusterTech Investments (HK) Limited, Fengqi Asia Limited, CTE (HK) Limited, CTAccel Limited, ClusterTech Beijing Limited, LianYuZhiDa Technologies (Beijing) Limited, Unimeteor (Beijing) Technologies Limited, CTData Limited and Cluster Technology Australia Pty Limited [6].

(2) Development of Artificial Intelligence and Big data

Artificial Intelligence techniques have been around for decades but are only being proliferated due to the availability of computing resources. Artificial intelligence (AI) is not a single technology; it is a concept that encompasses a variety of technologies (Fig.30), including natural language processing (NLP), speech recognition, and machine learning platforms. With increasing interest in corporations regarding AI, there has been a corresponding increase in AI related products. Machine learning has also already been made possible due to the availability of big data, which is growing exponentially due to the advancement of Internet of Things (IoT), where easily-deployed sensors can provide measurements at unimagined speed, and edge computing on devices like smart meters [6].

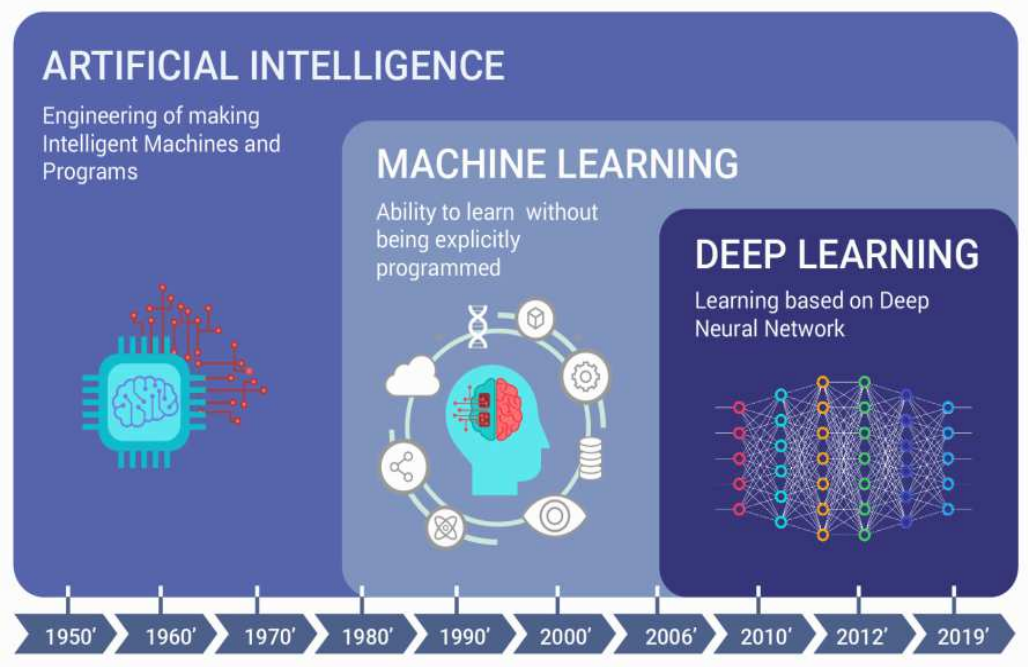

Fig.30 Development of Artificial Intelligence at ClusterTech

On the other hand, inventory management is always a challenge for retailers as it involves multiple parties and it is hard to optimise inventory levels over different products and stores. ClusterTech's customised inventory management solutions are based on retailer operation characteristics and sales records. By setting inventory rules and considering all parties involved, inventory optimisation uses artificial intelligence and data analytics technology to search and optimise the inventory level in different stores, as well as automate inventory transfer.

Throughout big data and IoT, ClusterTech contributes to increase business productivity momentum; reduce out of stock frequency, save buyer time with 100% logistic and operational compliance; achieve real time performance; make timely strategic decisions; improve user experience; increase workforce productivity and reduce labour costs. The takeaways of the digital transformation are summarized in Fig.31 below [6].

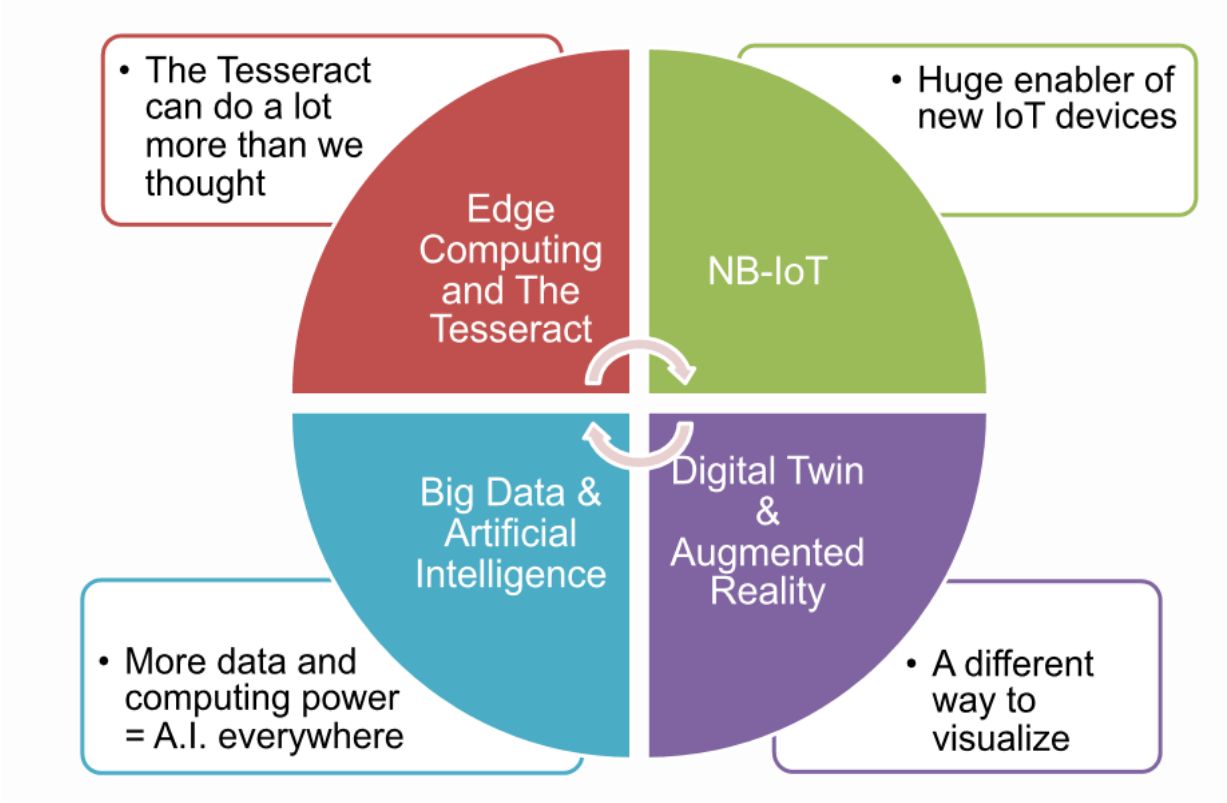

Fig.31 Takeaways of the Digital Transformation at ClusterTech

(3) Applications to Environmental Innovation

The digital transformation enables ClusterTech to corporate business efficiency, energy optimization, time-based rates, theft and leakage detection, building energy efficiency and optimization, value-added services to business tenants and various demand forecasts (Fig.32). Moreover, air dispersion analyst is a click-to-run online platform that is designed specifically by ClusterTech for air dispersion modelling analysis. Users can self-operate the platform and get results in a more efficient, reliable and flexible way.

Developed based on 10+ years Environmental Impact Assessment (EIA) project experience and supported by a large-scale parallel computing cluster, the platform achieves calculation speed of modelling far outpacing existing products with super low price while keeps high accuracy and stability. Now it provides modelling for AERMOD Atmospheric Dispersion Modelling System, which is required in Tier 1 assessment of EIA Reports by Hong Kong Environmental Development Department (EPD).

Other air dispersion models, such as Caline4 will gradually be put to use in this platform. Environmental consulting companies and research institutions, especially those having tight project schedule, or those with limited computational resources can benefit from Air Dispersion Analyst. For other air dispersion modelling and also PATH-2016 assessment, we now provide off-line professional solutions.

The air dispersion complies with guidelines enforced by the Hong Kong Environmental Protection Department, ensures accuracy of outputs using a powerful large-scale computing cluster specifically designed for AERMOD modelling with zero setup cost, low computing resources costs (saves up at 80%) compared to existing products or services on the market [6] .

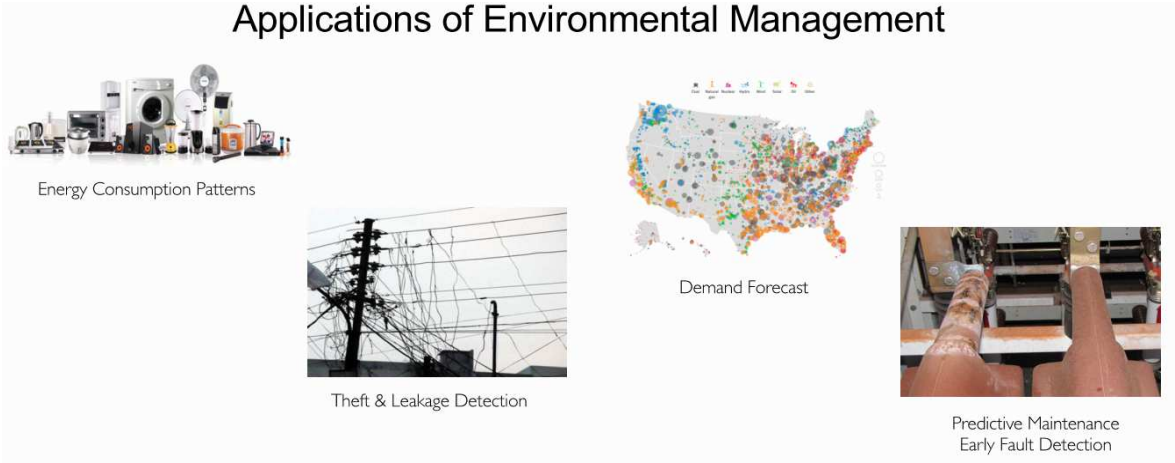

Fig.32 Environmental Applications of Digital Transformation at ClusterTech

4.4 **Challenges for Green Innovation Business Competitiveness**

As underlined by most of participants in the Forum, the environmental industry in Hong Kong is in urgent need of appropriate reforms to foster the development and promote green innovation despite of notably significant efforts invested in green innovation. The development of the sector is certainly hampered by various obstacles especially in the areas of specific policy, regulations, capacity building, public environmental awareness, incentives, local market environment, finance and technologies. Invested efforts are found globally insufficient, and local stakeholders come under criticism for lagging behind its neighbours and other comparable European and Asian countries. This situation, not only increases risk and uncertainty for environmental innovation business competitiveness but also inhibits the rapid growth of local demand market [12].

Weak demand from local market for environmental innovation due to low environmental awareness of customers, lack of information and promotional activities on emerging green products, technologies and services solutions, significantly hinder the development of the small and middle enterprises operating in the sector. Moreover, despite observed growing tendency for Government green procurement, the consumption of new advanced environmental technologies and products is still weak. This also curbs the interest and motivation for green innovation. The overall weakness of capacity building constitutes a major barrier to the development of the environmental innovation. Related critical aspects are education, information, mastery of new environmental technologies, continuous high quality professional development, and research ability in advanced green technology development.

Obviously, Hong Kong environmental innovation business is facing serious difficulties to meet and maintain a world class standard in human capital and new green technologies and services. As stated by number of participants in the Forum, green technology is identified as the most important advantage that differentiates a company from others in the fiercely competitive market. It is clear that the industry is highly dependent on technological innovations and development [7; 12].

In fast growing markets like China, investment in advanced environmental technologies is necessary for Hong Kong companies to hold a comfortable position. Unfortunately, limited financial resources and difficulties in banking financing (due to high investment risks associated with current market environment) exert great pressure on the development of Hong Kong small and middle companies. Therefore, building up a professional environment with adequate resources and all-round skilled stakeholders fully integrated into innovative and rapidly advancing technological needs, is crucial for Hong Kong environmental innovation industry to capture regional market opportunities [7; 12].

5-Conclusions & Perspectives

In sum, the development of environmental innovation in Hong Kong depends on the stakeholders' ability to boost local market and increase green consumption. Incontestably, local potential green innovation achievements could serve as exportable models for Hong Kong in grasping regional opportunities. Within this process, the consolidation and effective implementation of measures in place with successful achievement of existing targets are imperative. An important aspect is to enhance regulations on big data usage, digital transformation, green innovation for buildings, mobility, water, waste, air, energy usage, energy generation and supply in order to boost the expansion of green innovation and change the consumer taste for rapid growth of local environmental innovation market.

On the other hand, Hong Kong stakeholders must look towards building up the environmental industry with flourishing innovation, creativity, technological advancement and green services. The Forum highlighted plausible promising future axes such as green built environment, sustainable circular economy and "Smart City" for the breakthroughs of the environmental innovation in Hong Kong. However, the adhesion and full commitment of all stakeholders for the design and implementation of appropriate policy instruments and supporting measures appear necessary for long term economically successful innovations. Capacity building for innovation in line with market demand requires multi-disciplinary research cutting across several disciplines.

Therefore, new partnerships and closer links between stakeholders and educational institutions (both local and oversea institutions) at all levels, for improvement of information systems, vocational training, continuous professional development, support for small and middle enterprises, market studies and multidisciplinary research collaboration, are imperative.

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