STRIVE TOWARDS LOW CARBON AND SUSTAINABLE FUTURE - Different Stakeholder Engagement on Low Carbon Strategies

Edited by

Kah Hou Teng / Swee Pin Yeap / Ramani Bai Varadharajan

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Message from the Chief Editor

According to BP Statistic Review of World Energy 2020, carbon dioxide (CO_2) emission in Malaysia has amounted to 244.5 million tons in 2019, a rise from 243.5 million tons in 2018. The statistic shows Malaysia, as one of the contributing countries for carbon emission yearly in Asia Pacific, has been increasing from past ten years until now. In particular, our energy resource still depends heavily on crude oil, coal, and natural gas, which accounted to large amount of CO_2 emission. The Malaysian government has been contributing a lot of continuous efforts to reduce the carbon footprint by promoting the Low Carbon Cities Framework (LCCF). Carbon emissions can be reduced through the means how the cities are developed, how the resources are being consumed, how the energy is being use in the clean and green way. In fact, many cities in Malaysia have already set a low-carbon vision. Urban areas such as Kuala Lumpur, Iskandar Malaysia, Seberang Perai and Melaka have signed up to be members of city alliances,making their commitment to reduce the carbon footprints.

We are proudly to announce thats UCSI University take the leads to coordinate the new research consortium named 'UCSI Cheras Low Carbon Innovation Hub' to align with the Malaysian Development Plan RMK-12 Strategy plan. To be more specific, our research consortium align towards the

10 mitigation pathway towards the Kuala Lumpur low carbon blueprint strategy in particular on Action 4: Sustainable Energy System, Action 5: Community Engagement, Action 6: Low Carbon Green Building, Action 8: Sustainable Waste Management, and Action 9: Sustainable Water and Wastewater Management. Our vision of this research consortium is to support not only national but also international agenda in reducing carbon footprint. By collaborating with different academic experts, government agency, industrial stakeholders as well as local community, we aim to contribute towards "A greener better Kuala Lumpur".

I am deeply honored to take on the role in publishing the first book of our research consortium with the title of **"Strive towards Low Carbon and Sustainable Future - Different Stakeholder Engagement on Low Carbon Strategies"**. I hope that via the content of this book, we can share the knowledge of low carbon initiatives to more people including the academicians, the industrial practitioners, the governmental and non-governmental bodies, as well as the public. Let's move together in striving towards low carbon and sustainable future!

Teng Kah Hou

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Part 1

Technology in Low Carbon Development

Role of Carbon Capturing Technology in Low Carbon Development

by Shaukat Ali Mazari[a,b]

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CLIMATE change caused by greenhouse gas emissions, especially anthropogenic carbon dioxide, has posed a serious threat to the planet Earth. The signs of climate change, such as severe droughts, floods, storms, rise in the sea level, elevation in atmospheric temperature, melting of glaciers, and uneven distribution pattern of water cycle has recently escalated alarmingly. A lot has already changed due to the climate change, specially disasters due to the rise in average global temperature up to one degree Celsius. Under worst case scenario, also called business as usual, when no action is taken against carbon emissions, average global temperature may rise up to 5 degrees Celsius. On the carbon dioxide emissions, business as usual is no more an option for the survival of the humanity on Earth. To restore and sustain the planet Earth, it is inevitable to develop low carbon societies with advanced technologies.

Societies with a net impact of zero or minimal carbon emissions may be achieved through the countermeasures against carbon dioxide gas emissions

The societies with a net impact of zero or minimal carbon emissions may be achieved through the countermeasures against carbon dioxide gas emissions. This can be accomplished through the minimization of the use of the fossil fuels by meetings the energy demands by the renewable and sustainable energy resources. Matter of the fact is, the use of non-carbon or renewable fuel may be an option for the developed world with less than 20% of the global population, however, majority of the world still cannot afford such luxury. Apart from the energy sector, transportation, manufacturing, cement, steel and almost every other industry emits carbon dioxide. SoH, the use of renewable energy resources with zero net carbon emissions may be one of the options to reduce carbon emissions, however it cannot be a wholistic solution for the development of a low carbon world.

For a low carbon world, the development of viable carbon capture and conversion technologies is the need of the hour. The carbon conversion technology may be the future for low carbon development, however it lacks conversion efficiency and viability at present. On the other hand, even though carbon capture technology mimicking the natural gas sweetening process is at its mature stage, however it has yet to be viable for other carbon emitting plants. Currently, the cost of carbon capture technologies is so high for commercial scale implementation and may only operate for trial or regulatory purposes through government subsidies or stakeholder funding.

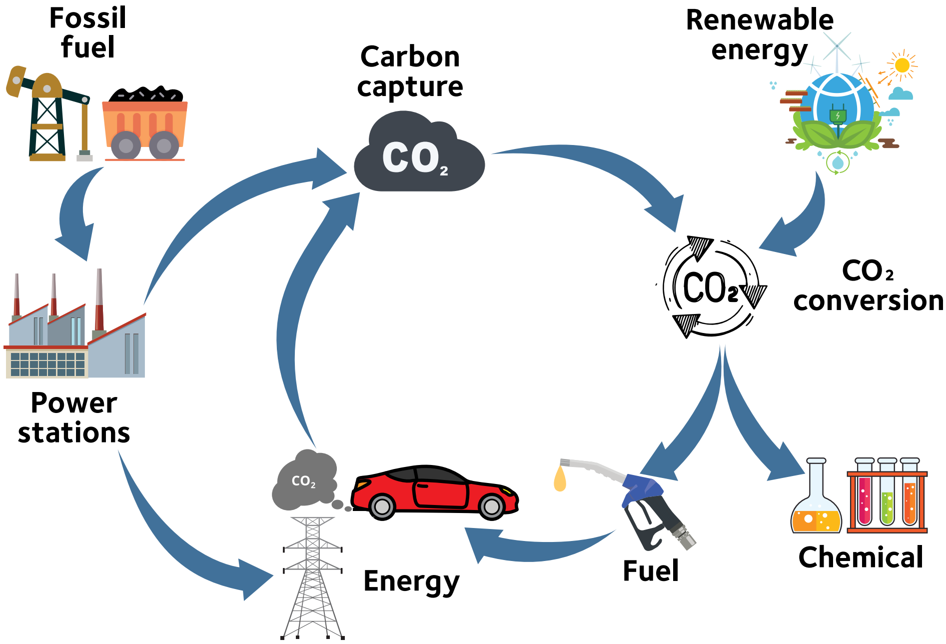
There is an array of carbon capture technologies. Some of them are operating at trial to large scale, others are still in the lab to pilot plant stage. Broadly, these processes are categorized based on the sources of formation of carbon dioxide and point of its capture, such as post-combustion capture, pre-combustion capture, oxyfuel combustion and industrial process such

as steel, fertilizer, manufacturing etc. Moreover, technologies are named after the mechanism of carbon dioxide capture such as absorption, adsorption, membrane separation, cryogenic separation, etc. The cost and flux of carbon capture is directly related with the specific technology and material used for the carbon capture. For example, carbon dioxide absorption using chemical solvents such as amines may be faster and in higher flux, however, the solvent regeneration cost is so high. On the other hand, using physical solvents may not impart a bigger regeneration cost, however, they capture smaller amount of carbon with lower absorption rate. Similarly, some adsorbents may have high carbon capacity with faster adsorption rates but their capital and regeneration costs may be higher. Without developing optimal carbon capture solutions with profitability or at least no losses, the commercialization of the technologies may not be possible.

Carbon capture alone is of no value, unless a suitable sink is found for the captured carbon, for example its permanent storage or its utilization for market product synthesis. The flux of captured carbon dioxide is so high that it cannot be consumed by the market currently for utilization, however, large-scale sinks, such as enhanced oil recovery and dedicated geological storages may be made into work. For large sinks, life cycle assessment of the stored carbon is of utmost importance for the sustainability. However, the future and viability of the carbon capture technology depends on its commercial applications and value addition. The potential value-added products can be found in a variety of types such as its mineralization to concrete, chemical synthesis for production of urea fertilizer, special polymers, synthetic fuels, syngas, methanol, etc. and its biological conversion for the growth of plants and improving soil quality.

Given the economic and technological disparity, the underdeveloped world or lower/middle income developing countries are nowhere near to the development of carbon capture technologies and their emissions are also low compared to the developed or bigger developing economies of the world such as China and India. The Center for Global development (CGD) has reported that from the industrial revolution till 2011, the developed world such as United States of America, European Union, United Kingdom, Japan, Russia and Eurasia has contributed to 79% of the global CO_2 emissions.

Even though, United Nations Framework Convention on Climate Change (UNFCC) has been taking efforts for the development of low carbon technologies and carbon capture. However, the inherited economic and technological disparity of the world is one of the biggest hurdles in achieving such ambitious goals to achieve the intended nationally determined contributions. The



A CO_2 conversion cycle (*Reprinted with permission from [Abdullahi Adamu et al. 2020] under CC BY 4.0*)

Adamu, A., Russo-Abegão, F. & Boodhoo, K. (2020). Process intensification technologies for CO_2 capture and conversion – a review. *BMC Chem Eng 2*, 2

carbon capture for low carbon emissions or development of low carbon technologies may only remain in policies and paperwork unless the developed world and UNFCC provides significant technological and economic support to the underdeveloped or low/middle income developing countries. On the other, the implementation of rules or sanction for the lower carbon emissions may push underdeveloped or low/middle income developing countries further to the poverty.

> **United Nations Framework Convention on Climate Change (UNFCC) has been taking efforts for the development of low carbon technologies and carbon capture**

Potential Technologies to Reduce Greenhouse Gas Emissions

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IN an era of rapid economic growth, the demand of getting energy from conventional fossil fuels has recently increased. The usage of fuels has increased the emissions of carbon dioxide (CO_2) and resulting in global warming as well as environmental climate change[1]. Based on Emission Database for Global Atmospheric Research, CO_2 emission in 1996 was 24.07 billion tons. Meanwhile, the CO_2 emission was 35.76 billion tons in 2016. It has increased greatly by 48.6% in only two decades[2]. This increment in global temperature is related to the elevation of CO_2 with time. In other words, the raising in temperature is because of excess CO_2 emission. Thus, CO_2 is the main cause of global warming [3].

To efficiently minimize the large amount of CO_2 in the surrounding, there are three methods can be applied, namely the application of CO_2 capture and storage (CCS), the implementation of policies to encourage renewable energy such as interest-free loans for purchasing renewable energy equipment and regulating emission limits for power plant, and promoting carbon neutral fuels usage, for example, hydrogen gas and ethanol fuel. By using these three CCS methods, 85% to 90% of CO_2 emission could be lower in total[1].

The three current methods for CCS are post-combustion; pre-combustion; and oxy-fuel combustion. The post-combustion system captures CO_2 from the flue gas after combustion[4]. The CO_2 in the flue gas is being diluted with inert gas under high temperature; 320°K to 400°K at 1 atm. For the pre-combustion system, it undergoes a reaction with air; oxygen (O_2). The purpose of designing the fuel's reaction with air in the process is to generate a synthesis gas named syngas. Syngas mostly contains carbon monoxide, and hydrogen gas (H_2)[5]. The CO produced flows to catalytic reactor react with steam forms H_2 and CO_2. Then, the CO_2 is collected to generate hydrogen fuels. The difference between post-combustion and pre-combustion are pre-combustion technique requires costly equipment to generate syngas and hydrogen fuel. The capital cost investment in this technique is high as it needs long-term development in areas to achieve efficiency target[6]. Meanwhile, the post-combustion technique is not required to change the combustion cycle. The flexibility given by this technique is allowing capture plant runs even power plant is being shut down[6]. Consequently, post-combustion gives a lower capital cost compared to pre-combustion.

The usage of fuels has increased the emissions of carbon dioxide (CO2) and resulting in global warming

In addition, oxy-fuel combustion process is different from the two methods mentioned above. It is being developed as an alternative approach to replace the post-combustion technique. Oxy-fuel combustion uses pure concentration O_2 gas for combustion rather than air. With this, a large amount of nitrogen element is eliminated from the flue gas stream. The product generated from combustion is steam water (H_2O) and CO_2. The steam water condensed and stored. The advantages are the output of CO_2 concentration is high and the separation of exhaust gases is easier. However, it requires a higher capital cost for the air separation unit that generates pure O_2 for combustion. Thus, electric power consumption and equipment maintenance are high[6].

In decades past, there are solutions used to overcome the weakness of conventional separation technologies. Nevertheless, membrane technology can provide more advantages other than previously discussed. In comparison between modern membrane technology for CO_2 separation and traditional separation, membrane separation takes lower energy and gives zero waste as membrane separation works via molecules diffusion. In addition, the implementation of membrane separation in the industry makes any modifications to the plant design system easier because the membrane can be scaled up easily without any additives[7]. In addition, membrane separation process can run constantly under mild condition; this flexibility makes membrane technology can be easily combined with others processes. Membrane needs to be replaced over time yet the overall cost is still suitable for commercialization[5]. In short, membrane technology not only provides high efficiency in CO_2 separation, but it is also energy efficient, cost-effective, and environmentally friendly[8].

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> “Three current methods for CCS are post-combustion, pre-combustion, and oxy-fuel combustion”

Nanoparticles - An Advanced Materials for Low Carbon Development

by Swee Pin Yeap[a,b,], Fei Wang[a,*], Wee Siang Koh[a]*

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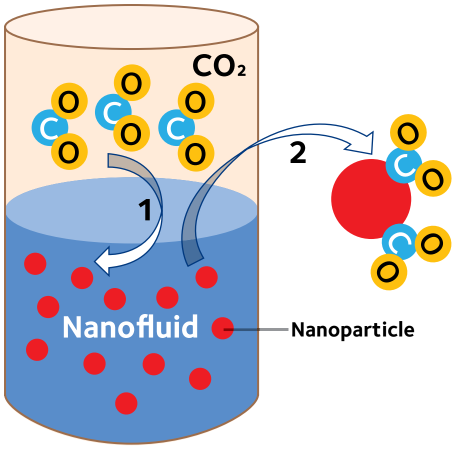
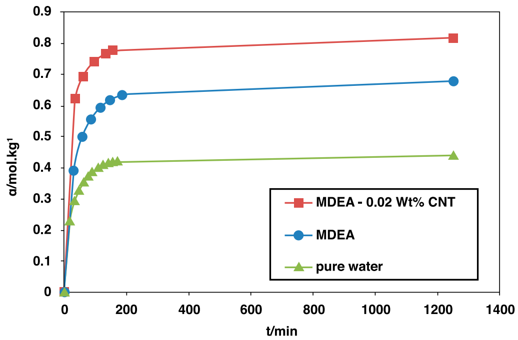
NANOPARTICLES are particles with at least one of the dimensions that fall within the nano-range (i.e. < 100 nm). Owing to the tiny size, nanoparticles developed a large specific surface area and other unique properties (such as thermal, magnetic, catalysis, mechanical, optical, and electrical) that are unattainable by their bulk counterparts. Over the past few decades, the applications of nanoparticles have gained the attention of many from lab-scale applications up to industrial-scale applications. Particularly, nanoparticles serve as an important entity in achieving low-carbon development.

One of the significant applications of nanoparticles is CO_2 capture and storage. Figure 1a demonstrates the uses of nanoparticles for the removal of CO_2 through physical absorption; it is

interesting to highlight that the physical absorption may serve as an alternative to the cryogenic or membrane methods which normally suffered from energy-intensive or fouling issues. A study by Rahmatmand and co-workers demonstrated that SiO_2 nanoparticles, Al_2O_3 nanoparticles, carbon nanotubes (CNTs), and Fe_3O_4 nanoparticles are feasible for CO_2 absorption[1]. Their results implied that adding 0.1 wt% of SiO2 in water and 0.1wt% of Al2O3 in water enhanced the CO_2 absorption capacity by 21% and 18%, respectively. Meanwhile, merely 0.02 wt% of Fe_3O_4 in water and 0.02 wt% of CNTs in water significantly improved the absorption capacity by 24% and 34%, respectively. Similarly, adding the nanoparticles in the methyldiethanolamine (MDEA) or diethanolamine (a conventional CO_2 absorbing solvent) can improve the CO_2 absorption efficiency (see Figure 1b).



(a)

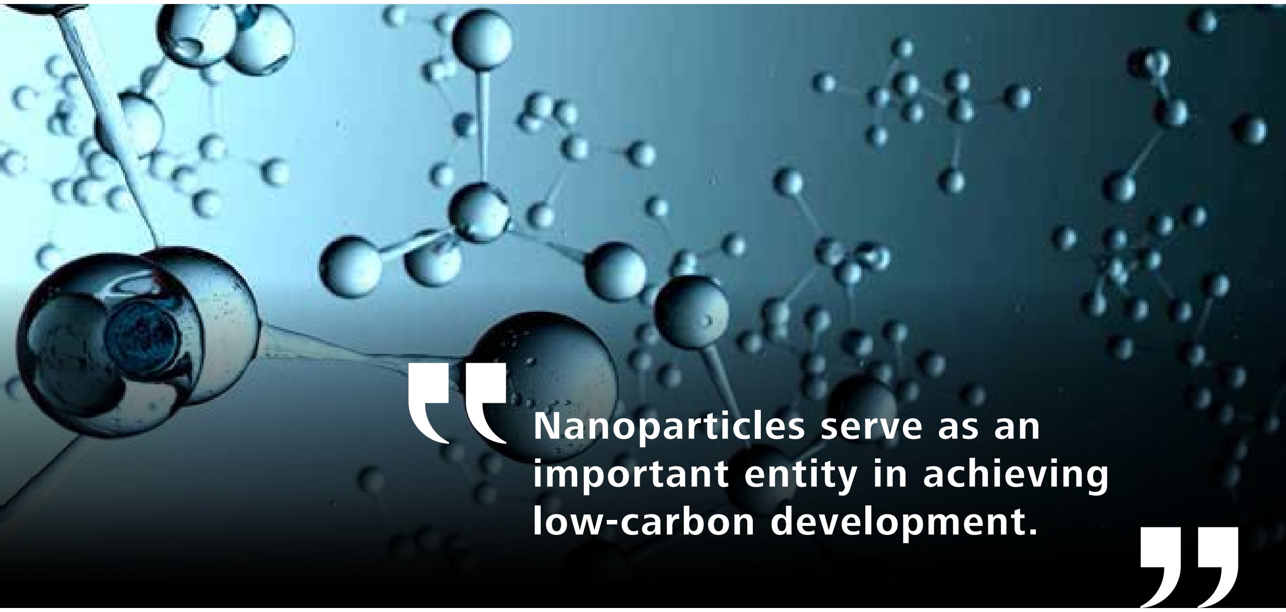


(b)

Figure 1: (a) Schematic diagram showing the uses of nanoparticles for absorption of CO_2. (b) The CO_2 absorption profile of MDEA aqueous solution containing 0.02wt% of CNTs as compared to absorption using MDEA alone or pure water (Rahmatmand et al. 2016). Copyright (2016) American Chemical Society)

Fundamentally, the CO_2 removal by nanoparticles was governed by a few possible mechanisms [1-6]: (1) the Brownian motion of nanoparticles develops micro-convection in the nanofluid which eventually increases the CO_2 diffusion from the air region to the nanofluid region; (2) the Shuttle effect promoted by the ability of nanoparticles to adsorb CO_2 in the gas-liquid interface and later on transport the adsorbed CO_2 to the liquid medium; (3) the Bubble breaking effect in which the irregular motion of the nanoparticles causes to the breaking of gas bubbles into smaller bubbles, the surface contact among gas and liquid phase and CO_2 solubility is therefore enhanced.

Despite being used for CO_2 capture, researchers have advanced the application of nanoparticles to the conversion of CO_2 into value-added products such as fuels, flammable substances, and chemicals [7]. In particular, CO_2 can be a feedstock for the production of ethanol; here, direct electrochemical conversion of CO_2 to ethanol was successfully achieved at high Faradaic efficiency and high selectivity under the catalysis of copper nanoparticle/N-doped graphene electrode [8]. In another study, Melo et al. successfully utilized ruthenium nanoparticles (2.5 nm in size) coupled with an ionic liquid to catalyse the conversion of CO_2 gas into methane (CH_4); high CH_4 yield was achieved at low temperature under such a catalytic system (Figure 2) [9]. In addition to ethanol and CH_4, the conversion of CO_2 to methanol [10], ethylene[11], propanol[12], and dimethyl ether [13] have been recorded. Thanks to the high specific surface area of nanoparticles, the catalysis and conversion processes can be run efficiently[7]. More interestingly, the activity and selectivity can be tuned based on the nanoparticle size [12].



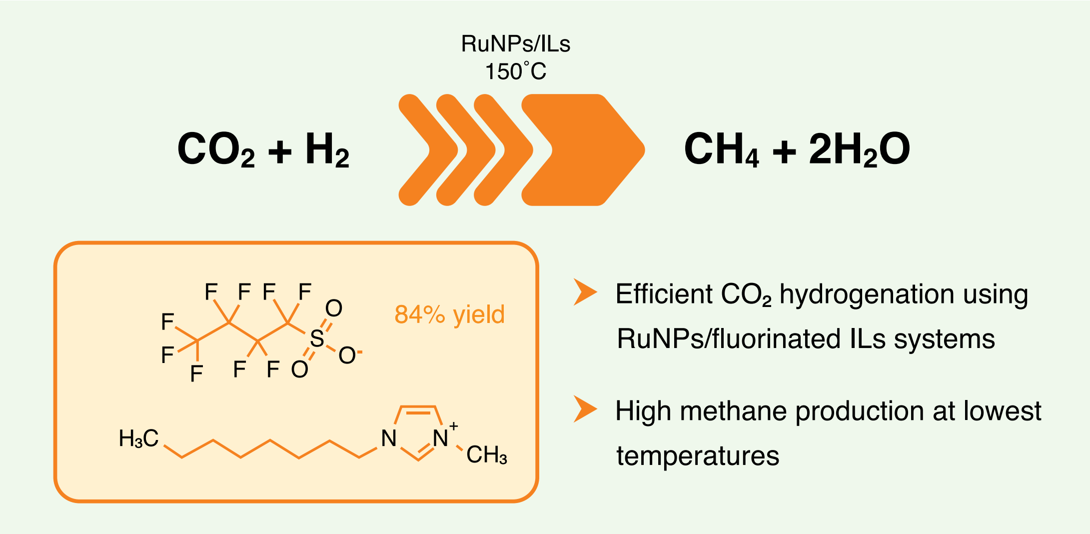


Figure 2: Schematic diagram showing the uses of ruthenium nanoparticles to catalyse the conversion of CO_2 to methane under a fluorinated ionic liquid system (Melo et al. 2019). Copyright (2019) American Chemical Society)

Another emerging usage of nanoparticles is in the field of low carbon fuel development. The blending of nanoparticles into low-carbon fuel (biodiesel) may significantly improve the brake thermal efficiency, decrease the ignition delay, reduce the emission of NO, reduce the emission of CO, and reduce smoke opacity [14]. Such an enhancement in engine performance was attributed to the role of nanoparticles as an oxygen buffer which provides additional oxygen for combustion [15]. Furthermore, the high specific surface area of nanoparticles enhances the heat transfer rates [14] as well as the catalytic behaviour leading to a reduction in exhaust pollutants [15].

To further achieve the net zero carbon aim, it is essential to reduce the amount of CO_2 released from the nanoparticle synthesis step. One of the strategies is to evaluate the carbon footprint of the synthesis process through a systematic life cycle assessment. In addition, recent studies have been venturing into the production of low carbon impact nanoparticles[16] and the production of carbon-based nanoparticles through CO_2 mineralization/consumption [17,18].

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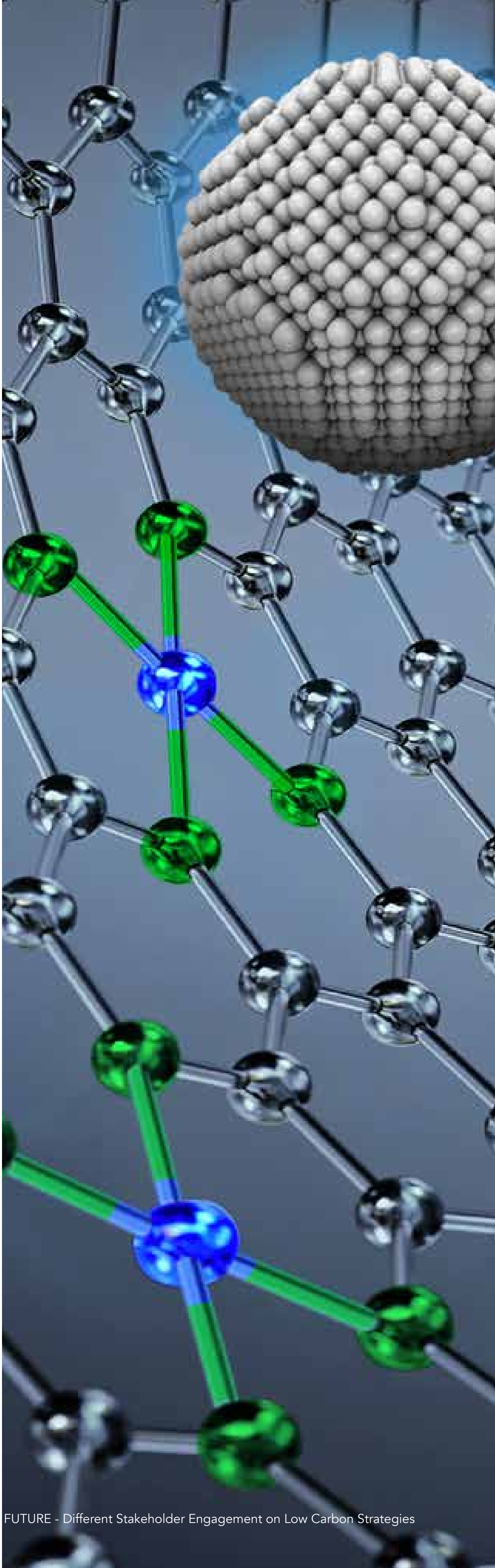
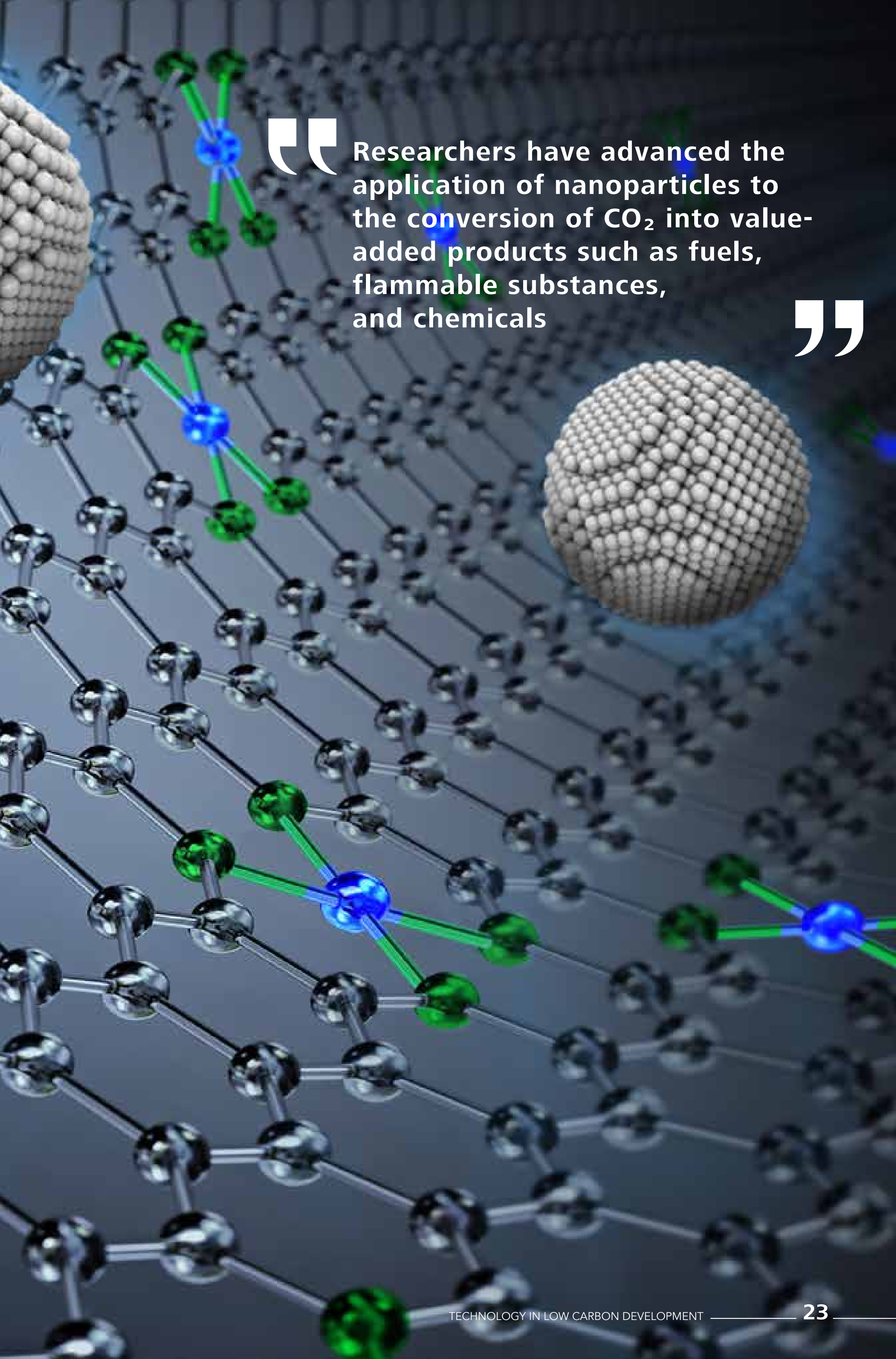
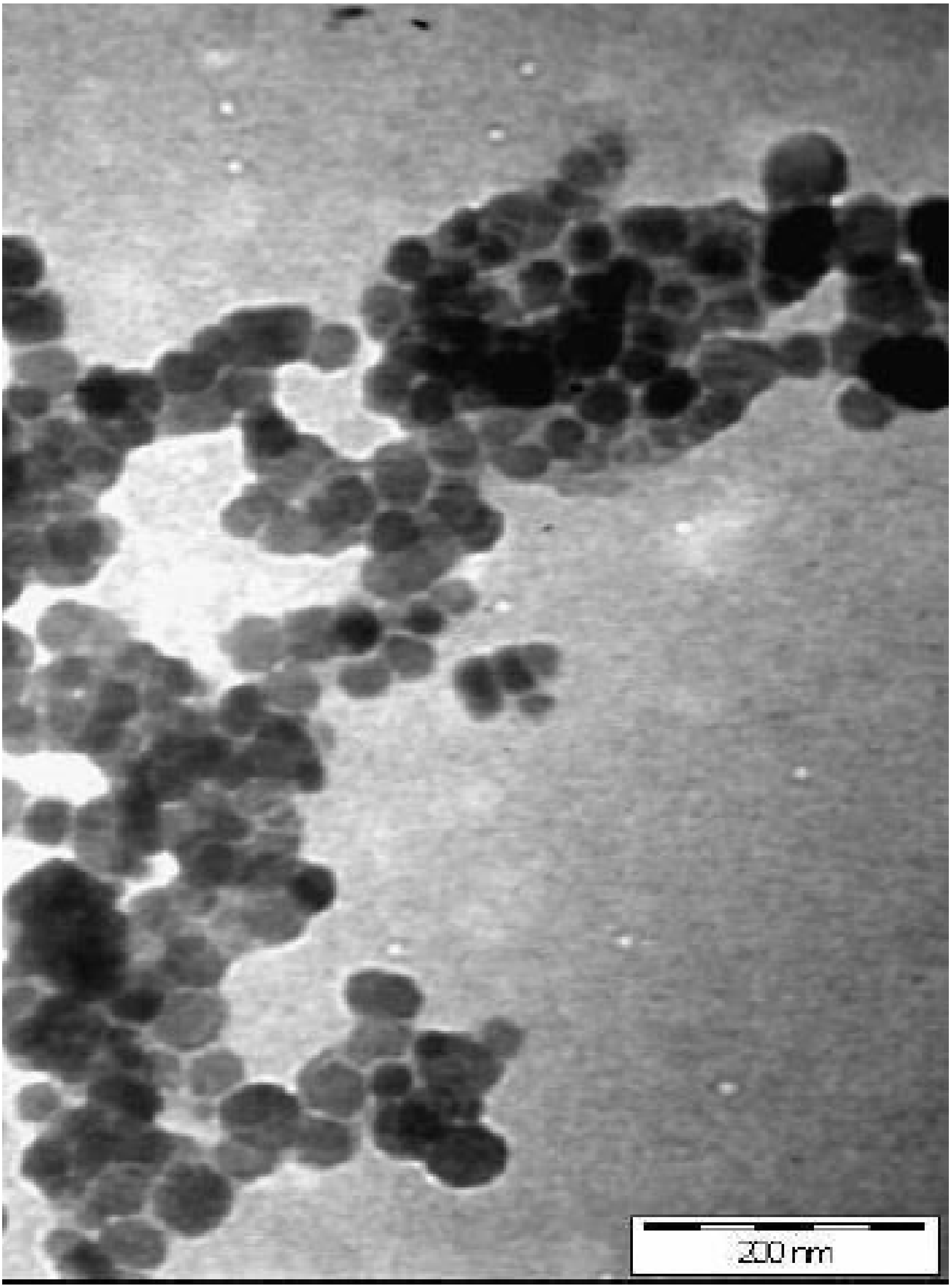




> **Researchers have advanced the application of nanoparticles to the conversion of CO_2 into value-added products such as fuels, flammable substances, and chemicals**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Part 2

Low Carbon Industry

Unleashing the Role of Green Fuel in a Low Carbon Economy

by S Mohan[a] and Akash Sinha[b]

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THE concept of a low carbon economy was first introduced by UK Energy White Paper (DTI, 2003) and is defined as obtaining greater economic output by reducing the combustion of fossil energy and lowering carbon emissions. Low-carbon development implies a gradual "decoupling" of the relationship between economic development and greenhouse gas emissions. A low carbon economy is a paradigm shift from the conventional fossil fuel-based economy toward sustainable development with fewer greenhouse gas productions. The energy-Economy-Environment system (3E system) is usually used to study sustainable development issues, which provides a systematic research perspective suitable for studying low-carbon transition. However, society plays a pivotal role in environmental protection. Hence, the low carbon emission transition needs to be assessed along with the social development and cost efficiency.

> **A fuel without carbon does not mean that it is carbon neutral**

Low Carbon Economy and the Nexus

The industrial revolution has resulted in the rapid growth of the industrial economy with a large amount of energy consumption, resulting in an extremely high level of GHGs emissions. With the current demand rate, the global economy has turned towards relatively cheap energy sourced from the combustion of fossil fuels. Currently, around

50 billion tonnes of CO_2 each year is released globally, which is 40% higher than emissions in 1990. CO_2 emissions reduction and low-carbon sustainable development have put the policy maker in a trade-off between the environment and the economy. The UNFCCC introduced the Kyoto Protocol to alleviate the effect of greenhouse gas (GHG) emissions on the environment. Out of the three mechanisms in Kyoto Protocol, a CDM is recommended as the best possible and flexible mechanism to control GHG emissions. CDM promotes an adaptive strategy to reduce carbon emissions, which puts Green Fuel as the potential candidate for low carbon emissions.

Green fuel

Fuels used for transportation account for discharges of more than 20% of all human CO_2 emissions. In addition, the power and industrial sectors emit about 44% and 22% of CO_2, respectively. Globally, road transportation constitutes about one-quarter of total greenhouse gas emissions (GHGs) (IEA, 2016). The International Energy Agency (IEA) forecasts that the emissions of CO_2 from the transport sector will

increase by 92% between 1990 and 2020. It is estimated that 8.6 billion tons of CO_2 will be released from 2020 to 2035. Currently, about half of the carbon dioxide released from burning fossil fuels is not absorbed by plants and the oceans, and it remains in the atmosphere. Anthropogenic CO_2 emissions come from the combustion of carbon-based fuels, mainly coal, oil, and natural gas. Fossil fuels are a problem for global warming because they release additional carbon that has been sealed away in the Earth's crust.

Burning fossil fuel increases the total amount of carbon dioxide in the atmosphere and is thus the prime source of climate change. A fuel without carbon does not mean that it is carbon neutral. Carbon-neutral fuel should be produced with the energy input derived from renewable sources and achieve net-zero carbon emissions in terms of energy consumption and carbon footprint.

> **Green fuels, also called green hydrocarbons or biofuels, are fuels produced from biomass sources**

Green fuels, also called green hydrocarbons or biofuels, are fuels produced from biomass sources through various biological and thermochemical processes. They can be utilized in engines without engine modification. The renewable feedstock is waste biomass that includes agricultural residues such as lignocellulosic biomasses (e.g., rice straw, wheat straw, and corn stalks), forestry residues, energy crop residues from food processing industries (e.g., olive mill wastewater and cheese whey) and organic waste such as an organic fraction of municipal solid waste, effluents from livestock farms, and effluents from aquaculture farms.

The choice of feedstock significantly impacts the technological development of biofuel production. For instance, edible oils and sugars are not ideal choices for the production of biofuels since the cost of the feedstock is high and their availability is unstable due to market competition.

On the other hand, using non-edible lipids, such as waste animal fat, has a lower cost. Biofuels production is either thermochemical, which involves pyrolysis, gasification, and Fischer Tropsch processes, or biochemical, which involves fermentation and transesterification. The sustainability of the pathways for producing liquid biofuels significantly depends on the type of feedstock used and the end product specifications. Therefore, there is no best pathway or solution to produce renewable liquid fuels.

Some of the potential green fuels are biodiesel, biogas, Hydrogen, and Ammonia. More than 350 oil-bearing crops have been recognized worldwide as potential sources for biodiesel production. Biodiesel feedstocks

"Financial sector has adopted new financing techniques, such as green financing and green credit, to promote growth and protect the environment."

come from edible and non-edible vegetable oil, animal fats, and waste oil. Biodiesel provides better performance for the vehicle but causes excessive engine wear. Biogas is another biofuel derived from different feedstocks, such as seeds, grains, sugars, crop residues, woody crops and algae. Hydrogen is a carbon-free fuel which could power vehicles via fuel cells with higher efficiency and less heat loss. The reaction products of hydrogen fuel are only water and a little heat without any GHG and carbon-contained atmospheric pollutants emissions. The high cost of storage, distribution and poor compatibility with the existing infrastructure are significant drawbacks in the large-scale commercialisation of hydrogen. Ammonia is one of the most abundantly produced chemicals in the world, of which 80% is used in the chemical fertiliser industry. Carbon-free chemistry, high hydrogen content, low storage and transportation costs, and strong feasibility for integration into the existing infrastructure show considerable promise as a fuel. However, increasing ammonia production is a challenge for the current demand.

Financial market and future of Green Fuel

The financial sector's role is essential in developing renewal sources as it requires enabling innovations, which is a long, distinctive, and inconsistent affair involving no guarantees of success and massive initial investment with long payback periods. The financial sector has adopted new financing techniques, such as green financing and green credit, to promote growth and protect the environment. The financial institution uses green investments and energy-efficient technologies to reduce environmental pressure. They also provide loans at low-interest rates to adopt clean technologies and R&D activities. The main obstacles facing a biofuel economy are costs, lack of technical knowledge, and infrastructure. Biofuels can rapidly evolve only if governments act seriously when facing security threats, climate change or drastic social or technological transitions. Concerning GHG emissions, significant uncertainty exists about the effects of a biofuel economy in short to medium run.

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AI-Based Approaches for Saving Resources and Energy in the Steel Industry and Manufacturing Sector

by Gregor Thiele[a]

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The accomplishment of a sustainable future is a goal that requires collaborative efforts on a global scale. The United Nations defined the Sustainable Development Goals accordingly with worldwide improvements of energy efficiency and increased resource-use efficient industries being two of their specific targets [1]. Due to the use of fossil primary energy sources both energy consumption and greenhouse gas emissions are coupled and can therefore be addressed together [2]. At Fraunhofer IPK, the monitoring and optimization of industrial energy consumption and sustainable production applications are central topics since the research project EnEffCo.

Production and supply engineering in the field of steel and manufacturing industry offer diverse systems with complex behavior. This makes them difficult to model and to control under the stipulation of high overall energy efficiency. A first step is the monitoring of energy consumption using appropriate software solutions [3]. Subsequently, advanced and predictive control are particularly popular to save energy in heating, ventilation and air conditioning systems (HVAC) [4], water supply [5] and in machine tools [6,7].

Because cooling and heating account for a significant share of energy consumption in industry, supply technology was the main focus of the research project EnEffReg [8]. Adjusting the temperature setpoints of a cooling tower and the chilled water distribution system resulted in energy savings of 775 MWh and a corresponding CO_2 equivalent of 310 tons over a five-month period. In a second application, the optimization of the cooling water supply led to energy savings of 1500 MWh per year and 600 tons of avoided CO_2 emissions [9].

For predictive control, the necessary system identification can be performed using AI-based methods. But these methods mostly leak plausibility. Thus, we used Sparse Identification of Nonlinear Dynamics (SINDy) for model learning [10]. Given a broad library of functions, SINDy deduces a set of just a few coefficients for a proper prediction. For modeling devices with a two-point-controller, we added a so-called hysteron. This extension allows SINDy to identify hysteresis behavior properly. Nevertheless, slow sampling or noise can distort the resulting model. To increase the robustness of this approach, we added a so-called proximity hysteron with tolerances [11]. Such approaches for data-driven system identification can be used to operate supply technology more efficiently [12].

In energy supply, the reliability of power stations is crucial. In the project EnerSec, we used Neural Networks (NN) with Long-Short-Term-Memory to detect anomalies in distributed energy generation [13]. These NNs offer a dynamic prediction of characteristic signals used to classify the current state of the entire systems. Thus, anomalies and especially dysfunctionalities can be detected earlier which helps to stabilize the power supply.

In order to apply advanced control, the system considered needs to be formally described using energy performance indicators (EnPI). Figure 1 illustrates a graphical model of an industrial cooling system by arranging the relevant subsystems according to their respecting energy- and information flows. At Fraunhofer IPK, we aim to use digital planning data of the facilities in order to apply monitoring and (AI-based) control easier [14]. Furthermore, the decomposition of coupled systems is an important step towards supervisory control, which may also involve AI-based models, as discussed in [15,16].

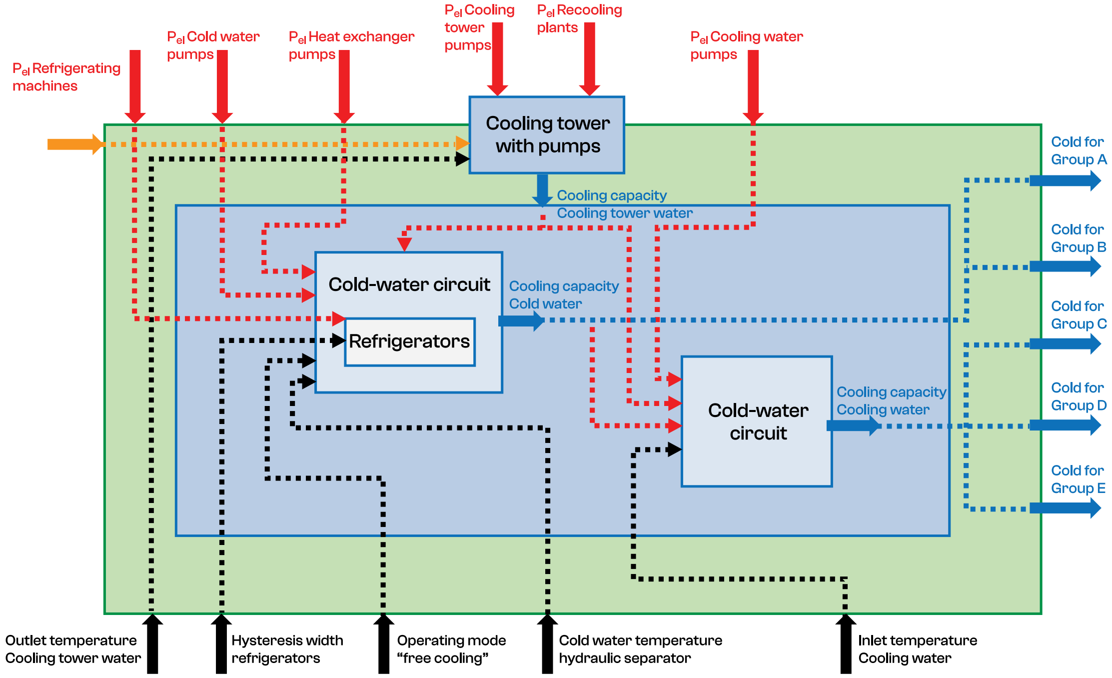

Figure 1:
Decomposition of a typical cooling system into functional units for using EnPI

> **A first step is the monitoring of energy consumption using appropriate software solutions.**

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Machine vision is a key AI technology for saving energy

NetsEco - Achieving Low Carbon Transformation towards Sustainable Business Ecosystem

by Soo Tyng, Teh

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The Strategy for Sustainable Civilization

Introduction

Conventional Printing has been the prevailing method that is utilized by society, the environmental impact of the printing process is high and includes: dust, emission of volatile organic compounds, waste plate, waste ink, wastepaper, waste heat, and noise. NetsEco, a brand by Nets Printwork Sdn Bhd started as a printer in 1997 recognize the importance of sustainability and has emerged as the Eco Printer focusing on balancing economic growth with positive social and environmental impact. Over the years, NetsEco had grown into a conglomerate of companies, who share the vision of a future where businesses and nature can coexist, looking beyond monetary gains and seeking to turn sustainability-focused business strategies into action.

Nets Printwork Sdn. Bhd.
(433608-M)
the heart of business strategy

The Turning Point: Green Transformation

Even before the UN's Intergovernmental Panel on Climate Change issued a 'Red Alert' for climate change on 9 August 2021, Nets Printwork was already well aware of the need to operate sustainably and had searched out and chosen solutions to minimise their carbon emissions and waste.

It successfully transformed itself from a conventional printer to an eco-printer way back in 2009. This was officially acknowledged by the Ministry of Energy, Green Technology and Water (KeTTHA) when its former minister, Dato Seri Peter Chin launched Nets Printwork's Total Eco Printing solution in 2011 and was witnessed by Dr. Nazly Mohd Noor, former CEO of Malaysian Green Technology and Climate Change Corporation (MGTC).

NetsEco®
Towards greener pastures

This was made possible with the development a sustainability management framework, the Eco Office Initiative Project (EOIP), which served as a guide, implementation module in the green transformation of the company.

An eco-printer goes beyond just using recycled paper and vegetable-based ink in our operation

as well as a sustainability framework and assessment tool to help organization in their green transformation process. The EOIP framework forms the basic foundation for an organisation to move towards a low carbon economy while enabling it to easily generate sustainability data for use in their sustainability reporting such as an ESG report.

Becoming an eco-printer goes beyond just using recycled paper and vegetable-based ink in our operation. Instead of merely be in compliance of sustainable practices, Nets Printwork has gone beyond compliances. The EOIP's framework has been developed to be flexible and robust, anchoring on four pillars of sustainable practices - Green Purchasing, Green Operations, Green Engagement and Green Growth.

The EOIP was developed to be easily replicable and adaptable for all industries

The Challenges in the Journey to becoming an Eco -Printer

The printing industry is one that contributes to unsustainable sourcing of various oils for the creation of ink as well as forest (deforestation). To reduce the negative environmental impact, we need to change the normal practices in our production process and office. We started with obtaining ISO 14001 environment management system certification, sourcing for eco ink, eco paper, eco machines.

Data collection is crucial in the sustainability journey to enable you to demonstrate the impact on major contributors to unsustainable practices such as area with high carbon emission in production. It takes long hours to train, engage with employees to submit their KPI reports.

We found it difficult to achieve the yearly reduction target on material usage and wastage because we keep increasing our printing machines from year to year. Table 1 shows the critical area of material usage and wastage in our production site.

> **The environmental impact of the printing process is high.**

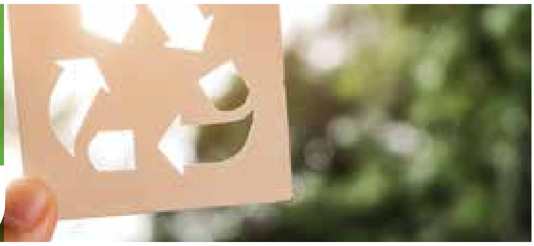
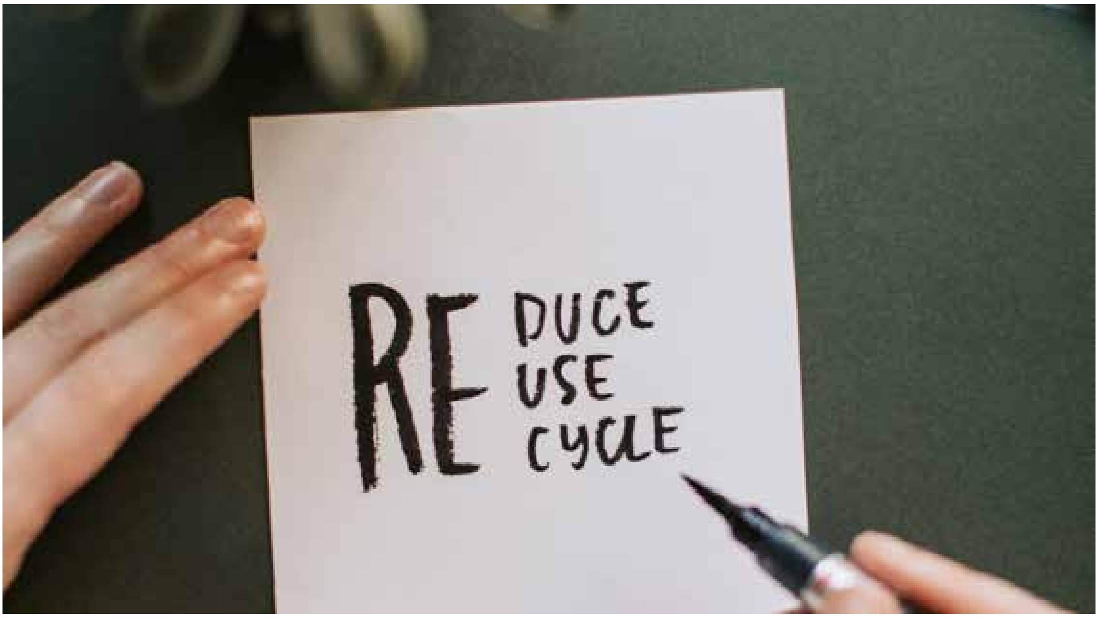


Table 1: The critical area of material usage and wastage in our production site.

Critical area of material usage and wastage	Changes and outcomes
Electricity consumption	Started to track, report and manage energy usage
Waste Plate	Started to upcycle, turn into merchandise. This helped reduce carbon emission as transportation to dispose of these items was cut down.
Used water, used cloths, used ink containers	Started to collected by license contractors
Ink	Change to vegetable based ink
Machine	Change to carbon neutral machines
Paper	Able to offer FSC, PEFC certified paper



The Solution - road to sustainable development

The EOIP was developed to be easily replicable and adaptable for all industries. It is not only a sustainability framework but also an assessment tool that can help organizations in their green transformation process. The EOIP framework forms the foundation for an organisation to move towards a low carbon economy while enabling it to easily generate sustainability data for use in their sustainability reporting such as an ESG report.

Utilising EOIP, Nets Printwork was able to streamline its operation against the three pillars of sustainability - Environmental, Social, and Governance (ESG) with the deployment of its established sustainability framework - Green Purchasing, Green Operations, Green Engagement, and Green Growth. These sustainability practices were developed to address the major impact a company might have on its environment, employees, customers, and the communities where it operates while ensuring continuous improvement to its sustainable growth.

The following showed the achievements based on the EOIP framework:

a) Green Purchasing

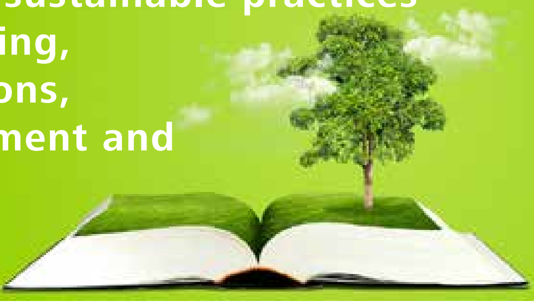
The green purchasing policy saw Nets Printwork using eco-stationary, eco toilet tissue, refurbished laptops at the office level while at the operational level it purchased Carbon Neutral Press and Computer-to-plate (CtP) machines and recycled stretched film for packing purposes at its printing operation. For operational maintenance, it reverted to purchasing only T5 and LED for lighting. The green factory managed to reduce 14 light tubes compare to their previous factory and the change to energy-saving light tubes save 1.68 KgCO2e per hour since 2015 (Table 2). This reduction in carbon emission is significant as electricity consumption (Scope 2) covers an average of 88% of the total organizational carbon emission for the past seven years.

Green Purchasing bring immediate solution by switching to purchasing materials from suppliers who practice sustainable operation e.g., ISO 14001 certified suppliers. This inevitably resulted in the company increasing its usage of green materials such as papers from the well-managed forest (FSC, PEFC), vegetable-based ink, etc. The impact has been positive, with the company's green purchasing rate averaging 10% per year. It was also able to influence the way the suppliers operate, hence creating more green demand in the market, especially for FSC certified paper with the supplier growing from one to seven in three years. 43% of our supplier is located within walking distance of our factory, this reduces the carbon emission of transportation.

Table 2: Comparing the old factory and green factory

Old Factory	Green Factory
102 light tubes for one machine area Total wattage: 4.08 kWh	88 energy-saving light tubes for two machines area Total wattage:1.584 kWh

Four pillars of sustainable practices - Green Purchasing, Green Operations, Green Engagement and Green Growth



b) Green Operation

At the operation level, Nets Printwork's implementation of the green operation programme saw it adopting the ISO 14001:2015 and ISO 9001:2015 integrated management system. The most significant gain is its purchase of environmental-friendly equipment. The eco offset printer cuts CO_2 emissions by 14 tonnes a year (based on 4,500 jobs per year and a paper weight averaging 100gsm) compare to the older machine. The new inking system also helped reduce ink and paper wastage.

In ensuring continuity in its sustainable agenda, Nets Printwork established several committees. This included the establishment of an ESH, EPMC, ERCMC, and Waste Management Committees. In addition, sustainability personnel was also appointed to ensure its permanent implementation and these included a Sustainability Manager as well as the creation of a Sustainability Department to lead the initiatives.

In 2017, the installation of 0.018 MW solar panel directly contributed to 2.8% savings in the energy portfolio.

c) Green Engagement

Green Engagement is about imparting sustainability awareness to its stakeholders. We need the community's effort to transition to low carbon workplace. With the establishment of the Eco welfare committee, it has organised several activities to enhance the understanding of green initiatives to the employees.

In addition, the sustainability department at Nets Printwork has continued to communicate internally (meeting, ESH training) and externally (Green Supplier Circle, Eco Sense SIP, talk) to promote green awareness in order to nurture the green culture around us.

Its engagement with its customers includes communicating and offering eco-printing materials to them (Eco label products & services) while imparting sustainability awareness to suppliers by communicating environment-friendly materials requirements.

d) Green Growth

Nets Printwork has continued to stay on top of industry trends by always staying relevant to industry change. This was made possible with the Eco Office Initiative Project (EOIP), which served as a guide in the implementation of the company's green transformation. It helped Nets Printwork:

- Become the first and only printer offering the SIRIM Eco Label, carbon footprint label, and carbon neutral label for printed material in Malaysia,
- Develop a sustainability strategy and roadmap,
- Using the life cycle approach in creating a sustainable operational framework to address its chain of operational,
- Collect corporate carbon emission data and implement an annual sustainability reporting system, and
- Won several PMHA environmental performance awards and sustainability reporting awards.

The Way Forward: Building a Sustainable Business Ecosystem

Nets Eco continues to stay on top of new development by following the call for transformation under the IR4.0 to ensure an integrated system for smart eco printing and eco packaging, reduce wastage of material and increase efficiency and effectiveness of the printing processes; increase usage of safer materials, resulting in improved performance and outcomes. With the implementation of IR4.0, autonomous printing and data control technologies have enabled us to monitor and provide real-time data, thus improving the global environment by producing green, resource-secure, and inclusive economies for all.

This journey has allowed us to come up with a new operational arm called Eco Sentido Sdn Bhd (Eco Sentido), aimed to share our experience & support organisations on their journey from business as usual to green compliance. In another word, to help businesses understand, implement and embed sustainability into their DNA.

Years into our sustainability journey, we realise that there is a need for more businesses to go green for Malaysia to achieve a low-carbon economy. For that to happen, we are progressively developing the EcoHub, a sustainable future living innovation hub, by inviting like-minded players to join NetsEco to build a dynamic and diverse ecosystem of experts from across our businesses, industries, governments, and beyond. Strong collaboration in private and public partnerships will accelerate appropriate and sustainable technological developments, scale-ups, and knowledge transfers to generate more social benefits and economic returns while reducing environmental impacts.

EcoHub will act as an epicentre of sustainable eco-business that provide the space, knowledge, and tools to accelerate the sustainability journey towards carbon neutrality by showcasing innovative solution, facilitating future-thinking discussion, and promoting collaboration & co-creation. The mission of EcoHub is to connect people, the planet, and profit.

A Project by Nets EcoVenture

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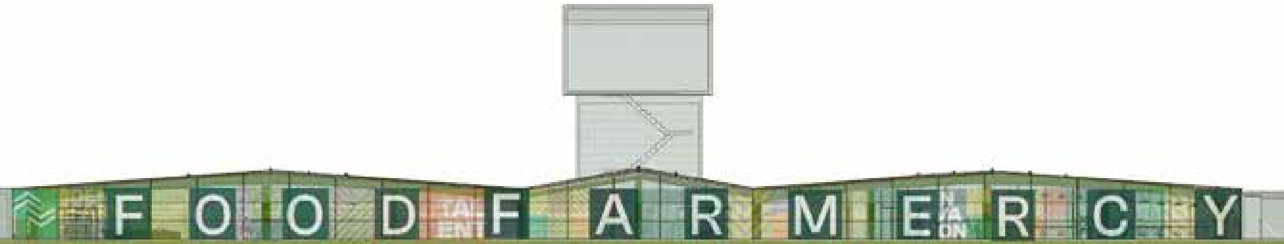
Sustainable Food & Agriculture
Technology Innovation Hub
MRANTI Park Malaysia.

DEMO FARM | FOOD HUB | INNOVATION HUB | TALENT HUB | LIVING HUB



Revaluate agriculture for Sustainable Food Systems

The first phase of EcoHub will kick start with Food Farmercy, a sustainable Agri-FoodTech Innovation Hub which is designed based on the concept of Sustainable Food Systems to ensure healthy and nutritious food for ALL. The hub aims to demonstrate a sustainable business model that could contribute to local communities by creating job opportunities, and provide healthy & nutrition food while showcasing Agri-FoodTech as a dynamic sustainable future living laboratory, demonstrating practical climate solutions by accelerating the adoption of sustainability policies & initiatives.

We believe that by connecting the dots across all that we do – as an individual, talent, consumers, business partners, investors, regulators, etc – we can make a huge impact on a sustainable future and shape a new era of eco lifestyle in Asia.

Explore more stories & collaborate with us at **www.netsgroup.com.my**

Note:

ESH – Environment, Safety & Health

SIP – Structured Internship Programme

EPMC – Environmental Performance Monitoring Committee

ERCMC – Environmental Regulatory Compliance Monitoring Committee

PMHA – Prime Minister Hibiscus' Award

Green purchasing refers to the adoption and implementation of a green purchasing policy where it applies to purchasing activities for goods and services for its own internal consumption as well as for external party usage.

> **There is a need for more businesses to go green for Malaysia to achieve a low-carbon economy**

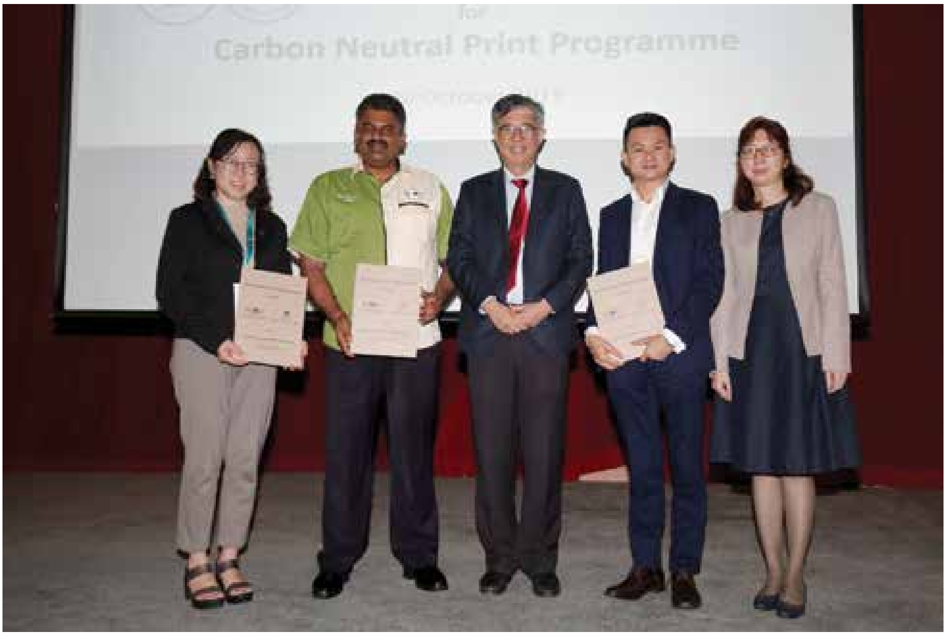
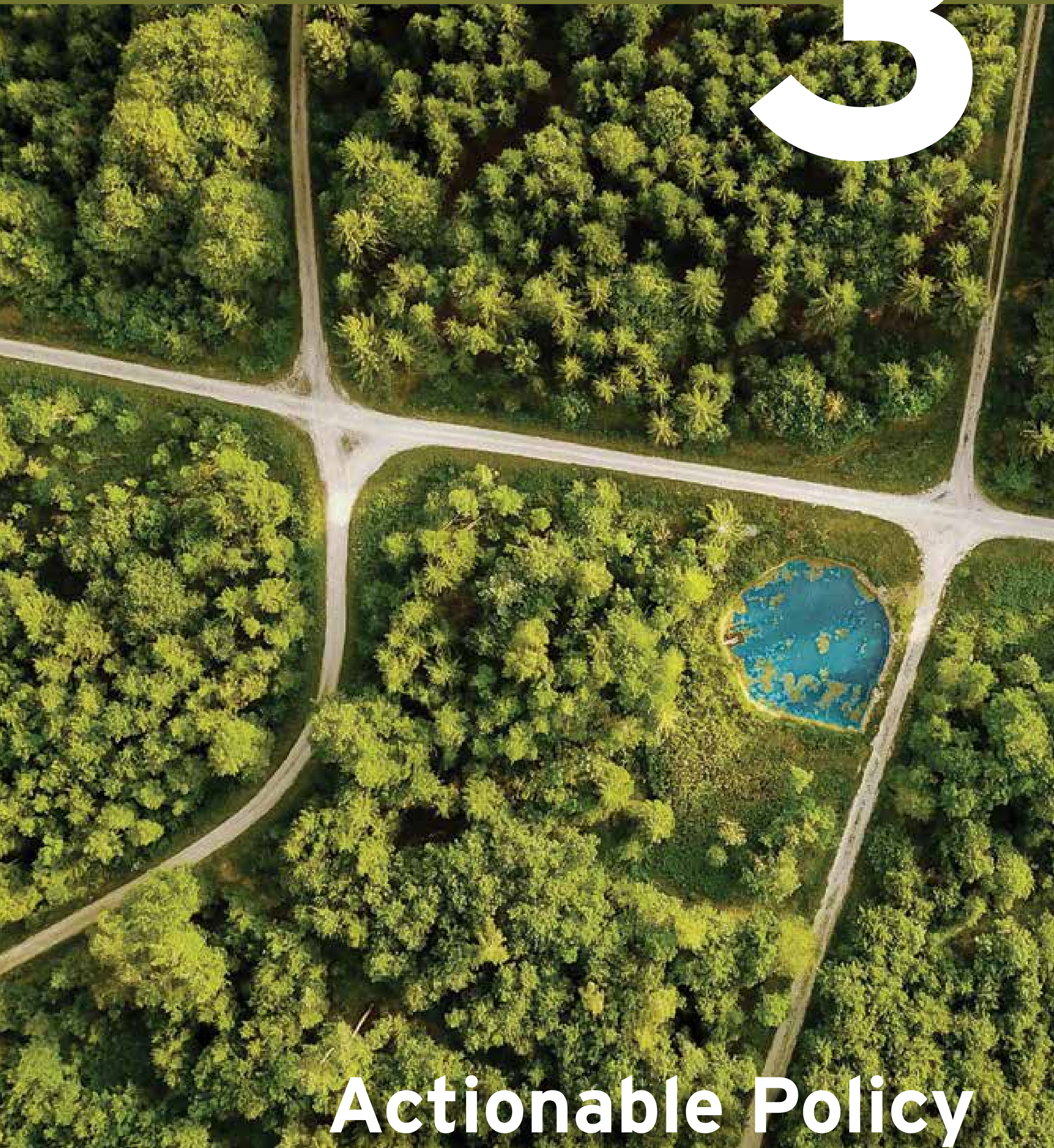


Photo 1:
The exchange of Memorandum of Understanding (MoU) for Carbon Neutral Print Programme (CNPP) between Nets Printwork Sdn Bhd and Malaysian Nature Society (MNS) and Global Environmental Centre (GEC) takes place during the Eco Sense Talk. (From left: Ms. Adelaine Tan from GEC, Mr. I.S. Shanmugaraj from MNS, YBrs. Chua Tian Chang, Managing Director of NetsGroup, Mr Teh Leong Sim and Sustainability Director of NestGroup, Ms. Teh Soo Tyng)

Part 3



Actionable Policy is Needed!

We Need Actionable Policy for Low Carbon Development

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The world has begun to take notice of climate change. The warning signs of global warming, the principal driver of climate change, are becoming clearer by the day. Only recently, many parts of Europe went through one of their worse heat wave ever recorded. Many among the elderly succumbed to the heat stroke. Floods have also occurred more regularly around the world. And they have become more extreme and also sudden, taking people by surprise. Many cases of flooding have also occurred because of man's failure to comply with warnings given by environment impact studies. There is no denying that the most vulnerable of the world population are those living on low lying islands. Sea level rise driven by the melting of the Arctic ice, as a result of global warming, is no longer deniable. Marine scientists have produced convincing evidence of this happening. Unless immediate actions are taken to arrest the worrying rise in global temperature, it is not impossible that humanity will soon have to say good bye to life on earth.

Scientists have singled out carbon as the main culprit in climate change. The uncontrolled emission of carbon gases, principally carbon dioxide, has been identified as responsible for the global greenhouse effect. All other gases are measured as carbon dioxide equivalent. The latest that has been reported is that the level of GHG emissions has surpassed the 400 ppm mark. As the level moves up, global temperature rise will follow. Scientists have warned that we should not exceed 1.5 degrees Centigrade. Anything beyond may even be irreversible. The United Nations Framework Convention on Climate Change, UNFCCC, meets yearly to deliberate on the latest developments and debate on the necessary actions needed to rein in the global carbon emission and the consequent temperature rise. Civil society groups have been campaigning for businesses to toe the line in reducing emissions. Lately, we have seen encouraging response from businesses as the concept of Environment, Social and Governance, ESG, is now taken more seriously. It is not just customers who have been pushing businesses to revamp their business conduct. Even the investor community has begun shying away from businesses which flout the SDGs.

> **Low carbon is now the name of the game in businesses.**

Low carbon is now the name of the game in businesses. Failing to comply with the global push to reduce carbon emissions can even be fatal. Governments everywhere have put in place the necessary policy instruments for low carbon. Cities which are widely seen as a major contributor of global emissions have largely declared to pursue the low carbon agenda. Kuala Lumpur has also produced a low carbpn blueprint as it strives to join the league of smart cities. But progress has been anaemic. It is difficult to change old habits. Cheras is a major suburb of Kuala Lumpur. Going low carbpn remains a struggle. Remember the notorious Cheras crawl. It is still there. This is despite the construction of highway after highway to disperse the traffic. The worst spot has to go to the part of the Cheras-Kajang highway on the opposite side of the lone toll booth left. Many are asking when is that toll booth going to be demolished. The highly congested road is in the direction of the city centre. The worst congestion happens daily each morning especially on working days. The MRT for some reasons does not attract enough clientele. Residents of Cheras and the neighbouring communities still prefer to use the car. It has a lot to do with the yet to be resolved last mile issue, from the house to the station and from the station to the workplace.

The latest news is that Cheras residents have submitted a public petition protesting over the state of development in the area. According to the petition, the residents are not happy with the many high rise high density condominiums that have sprung up in Cheras. They question whether there have been adequate social impact assessment studies being undertaken. Or for that matter the traffic impact assessment of such projects. I am sure the residents who have lived there for years know better the sufferings they had to endure. For us non-Cheras residents we only feel the discomfort whenever we pass through that infamous stretch. It is time for the authority to seriously rethink such an urban development policy. The irony is that this is happening at a time when Kuala Lumpur is seriously implementing the city's low carbon blueprint. This is part of the country's NetZero plan to comply with

the global effort to reduce emissions. Since cities are known to be a major source of carbon emissions, cities have been targeted to deliver the major chunk of the NetZero targets. Related to this, the country has also launched the nation's smart city framework which is helmed by the ministry of housing and local government. The smart city framework talks about 7 components which include smart mobility and smart living. Traffic congestions definitely work against the aspirations of smart mobility. Whilst, high density living with reduced open spaces contradict the objectives of smart living.

The other component of the smart city framework is smart environment. The major concern here is wastes. Often, cities face major challenges managing their wastes efficiently. The higher the population density, the larger the amount of wastes produced and the more difficult and costly to reduce their negative environmental consequences. Related to smart living, the other concern which stood out prominently during the pandemic is the strong correlation between the spread of infectious disease and high density living. As we are constantly being warned that such public health scare may not be the last, there is all the more reason to move away from high density living.

Experts in urban planning have been calling for a strategy of population dispersal in the big cities, rather than continue with population concentration. The population of Kuala Lumpur may have reached the tipping point here. Instead of continuing with business as usual, we may want to consider dispersing the population to the outer klang valley and at the same time investing in a wide network of public transport. That way we would have a better chance of not only delivering the low carbon mandate but also move closer to meet the smart city criteria. The much touted Vision Valley earlier announced by the government may be a good target to start with.

It is clear urban development has come under much scrutiny lately. The pandemic is a factor which has hastened such interest. The other driving force is of course the global push towards NetZero which the world desperately needs to cool down global warming. It is predicated that soon more than 70% of the world population will reside in cities. This makes cities the hotspots for carbon emissions. Tackling emissions in the urban metropolis is the smart way to reduce emissions. And over-development will definitely negate that. This is where any low carbpn policy unless accompanied by actionable plans is destined to not deliver.

> **It is time for the authority to seriously rethink such an urban development policy**

Index

UCSI-Cheras Low Carbon Innovation Hub Research Consortium

UCSI-Cheras Low Carbon Innovation Hub Research Consortium is a research consortium established by UCSI University in Malaysia to address the thrust areas aligned with the National Prosperity Vision 2030. The consortium aims to contribute towards reducing carbon footprint by accelerating the development of Low Carbon Cities in Malaysia.

The consortium is formed by a team of renowned researchers from Malaysia and the UK, and it works with industrial partners, governmental bodies, NGOs, academicians, and researchers from leading local and international universities to attain knowledge transfer, community care, embrace sustainable goals, and green economics. The consortium's mission is to contribute towards "A Greener Better Kuala Lumpur" KL Low Carbon Society Blueprint 2030 along with support on the carbon footprint reduction in the global agenda.

The consortium is organized into Five (5) main pillars, which provide offer towards low carbon initiative in (i) IR 4.0, (ii) Renewable Energy, (iii) Environmental Science, (iv)

LOW CARBON INNOVATION HUB EXPERTISE

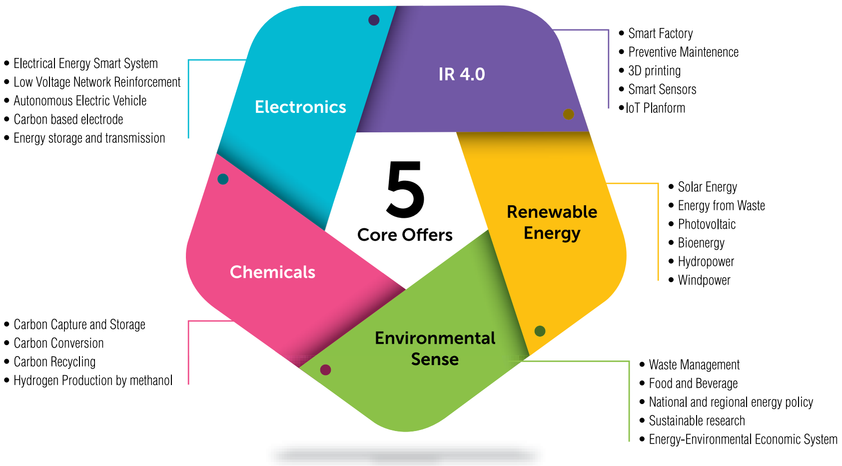

Figure 1 further shown th

Figure 2. The launching of UCSI-Cheras Low Carbon Innovation Hub Research Consortium

Chemicals, and (v) Electronics. Each project proposed by the consortium is part of the strategies to achieve the vision and mission of the consortium.

The output from this consortium may impact society, industry, economy, and environment by making low carbon initiatives a public knowledge, promoting more business models and job opportunities, establishing a green economy, conserving the environment, and contributing to national policies.

While this is a research consortium, the consortium aims to stand out as a recognized group in this area of research by journal publication, grant securing, and forming a strong research network. The consortium is committed to making a positive and significant impact on climate change. The UCSI-Cheras Low Carbon Innovation Hub Research Consortium represents a significant step forward for UCSI University in research, and it is a key contribution to the global effort to address the challenges of climate change.

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Wind energy promotes sustainable development in India

Wind energy, Tuppadahalli, India

Clean power generation through wind turbines. This is just one of the many benefits of the project in the southern Indian state of Karnataka. Several small wind farms in the districts of Shimoga and Chitradurga generate clean electricity with a total of 34 turbines and a total capacity of 56 MW, which is fed into the Indian grid. The low-emission technology thus contributes to the reduction of greenhouse gases. At the same time, the project secures the energy supply in regions that previously had no constant access to electricity.

In addition to improved electricity supply, the project also facilitates the SWABALAMABAN programme, which provides vocational training for unemployed youth from local villages, such as electrical wiring, tailoring, agricultural activities or driving lessons. With education programmes as well as the establishing job opportunities for the local population the project supports the sustainable development of the region.

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How wind energy contributes to climate action

As the name suggests, wind turbines use the power of the wind to generate energy. During this process, a generator located inside the wind turbine converts kinetic energy into electrical energy. As energy is still mainly generated from fossil fuels in many areas around the world, clean wind energy can replace some of this fossil, high-emission energy and verifiably save CO_2 emissions.

In most cases, the sustainably generated electricity from the wind power projects is fed into a regional power grid, which diversifies the power supply and improves energy security in regions that are frequently affected by power shortages and outages. A project often creates increased job opportunities for the local population and the area can be used for additional activities, such as agriculture. Wind power projects make an important contribution to a clean energy supply worldwide and contribute to sustainable development with respect to the UN Sustainable Development Goals (SDGs).

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Contribution to the UN Sustainable Development Goals (SDGs)

SDG 7 · Affordable and Clean Energy

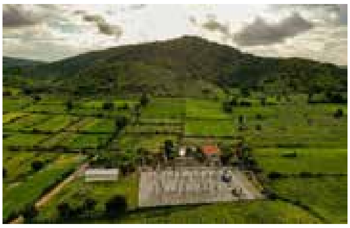
The project increases the share of renewable energy in India.

SDG 8 · Decent Work and Economic Growth

The project activities create long-term as well as short-term job opportunities for the local population. With a programme for vocational training, it also helps young people to secure jobs in the region.

SDG 13 · Climate Action

The project saves about 128,800 tonnes of CO_2 per year.



Project standard
Verified Carbon Standard (VCS)

Technology
Wind energy

Region
Tuppadahalli, India

Estimated annual emission reductions
128,809 t CO_2e

Validated by
Bureau Veritas Certification Holding SAS

Verified by
Applus+ LGAI Technological Center, S.A

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