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Access to Energy

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EDITORIAL

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Renewables for SDGs

A recently published report mentions that renewable energy investments must scale up to meet Paris Agreement Goals and the implementation of SDGs. It estimates that US$90 trillion of investment in climate projects is needed by 2030. The report has identified six SDGs which get direct benefits from increased green investments. These are SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 9 (industry, innovation and infrastructure), SDG 11 (sustainable cities and communities), SDG 13 (climate action) and SDG 15 (life on land). However, investments alone will not result in the implementation of SDGs. There are other ecosystem enablers which are required to meet the ambitious targets of SDGs by 2030. The first set of enablers are associated with management and governance aspects. For instance, the stringent time lines for meeting the targets require quick and effective decision- making that rests on our ability to synthesize and analyse the data and information. Further, the execution of decisions requires strong governance structures, systems and process. It also requires a good coordination and cooperation amongst policy makers, think tanks, industry and the public for their decisions and actions.

The second set of enablers require an understanding of the interrelationships and nexus between energy, water and agriculture;energy and poverty alleviation; energy and climate vulnerability etc. and the complexity of challenges arising due to such nexus. Thereafter, customising the interventions/ solutions to address the complex challenges, and then standardising them for a rapid scale-up.

And finally, an ecosystem to absorb innovations in technologies that have already started to make their impact in other related sectors. For example, blockchain has played a significant role in electricity sector by introducing smart contract that has eliminated the requirement of third-parties and intermediaries. At the same time, there has been an overall improvement in the operations, transparency and security of the system. Iberdrola, the major Spanish electricity utility, announced recently that it has completed a successful blockchain test which will enable the power supply that is 100 percent renewables. The ecosystem enablers would ensure a good Return On green Investments that will help in achieving the targets of SDGs.

DTOcean: Marine Array Optimisation

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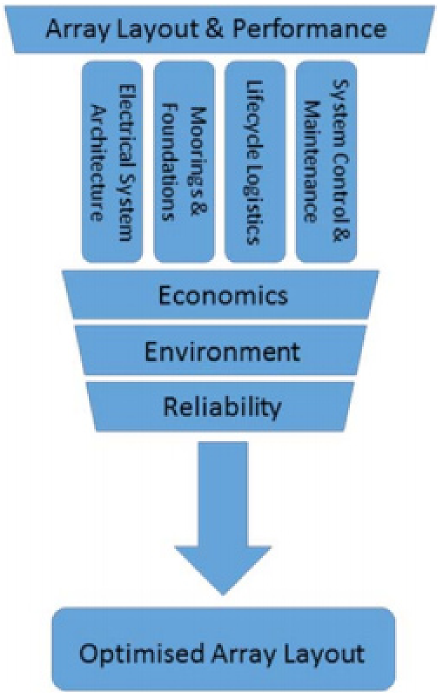
DTOcean stands for Design and Optimisation Tool for Ocean Arrays. DTOcean aims at accelerating the industrial development of ocean energy power generation knowledge and providing design tools for deploying the first generation of wave and tidal energy converter arrays.

The DTOcean project was a three-year collaborative project funded by the European Commission's 7th Framework Programme (FP7). The project involved developing a suite of design tools for wave energy and tidal energy developers to evaluate the impact of design decisions against quantitative metrics such as the levelized cost of energy (LCOE). The tools can be used to evaluate numerous design choices relating to device hydrodynamics, electrical sub-systems, moorings and foundations, and installation and O&M activities.



Role of ITPE

A hydrodynamic model was developed by ITPE to optimise power production of tidal arrays along with an algorithm to automate the sizing, routing and protecting of cables for the transmission and the intra-array cable networks. The enabling technologies were incorporated into a work package which involved- identifying and assessing technologies that should be used more, developed or improved in order to increase reliability and production of marine energy arrays.

What does the software do?

The open source software allows developers to rapidly assess and automatically optimise array layouts at different sites to aid the site selection process. The software evaluates each stage of the design process, and then the design as a whole, using three assessments:

- Economics
- Reliability
- Environmental

The software seeks to optimise the layout to reduce the LCOE and environmental impact as much as possible.

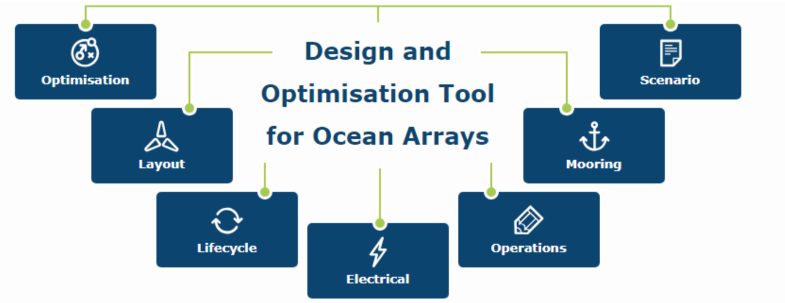
Tool description

DTOcean work planning has been implemented as five content-orientated Work Packages. These are:

1. Hydrodynamics,
2. Electrical Sub-systems,
3. Moorings & Foundations,
4. Installation
5. Operations & Maintenance

These five work packages are guided by two defining work packages- Scenarios and Management & Coordination. These two basically support the selection from a range of array sizes and hydrodynamic layouts. The outputs, feedbacks and interactions within from these work packages is then integrated and this is where the design tools are developed.

The structure of these work packages is set out below. There is considerable collaboration and interaction between all work packages. Together they deliver an integrated approach to ocean energy array design and development.



Siphonic Roof Drainage is a Sponge City Technique

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The SPONGE-CITY concept was originally created by Chinese authorities in response to the devastating floods in Wuhan, Nanjing, and Beijing in 2012, where at least 37 people died. Today, the SPONGE-CITY concept is discussed and implemented in the town halls of all major cities worldwide.

The Sponge City concept includes a variety of measures to mitigate urban flooding. Rainwater retention through structural measures plays a major role in this concept. Rainwater evaporation also relieves the sewer system and improves the climate in cities.

In the following sections, we would like to present a particularly effective and economical rainwater retention system.

Siphonic Roof Drainage (SRD): Retention at No Extra Cost

With SRD, full drainage starts only when the pipe system is filled completely with rainwater and the required water depth close to the roof drains is reached. This time lag is desired and can take a few minutes depending on the structure. This retention is the simplest and cheapest method because no additional equipment is needed. Only inspection and maintenance of roof drains and pipework are required.

If longer retention is required, SRD can be combined with short-term storage of larger quantities of rainwater on the roof. Here is how it works in a few words:

If the design rainfall is reached and the pipework is completely filled with rainwater, then drainage starts abruptly. If the design rainfall is exceeded and heavy rainfall or even higher rainfall set in, the drainage capacity stays almost constant anyway and has a throttling effect. The rain quantities which exceed the design rainfall are now temporarily stored on the roof.

The roof construction needs to be watertight up to an appropriate level and the additional roof load has to be taken into consideration.

For retention combined with siphonic roof drainage, two different roof designs seem to be suitable: on the one hand a flat roof with a water depth of up to 50cm and on the other hand a low-sloped roof with valley gutter.

Flat Roof with Siphonic Roof Drainage

Because of the considerable retention and high roof load, a concrete roof structure is imperative. The retention required at the location of the building can be determined by the height of the massive parapet walls. A water depth of 50cm roughly corresponds to a catastrophic storm, which occurs once in 10,000 years. This construction is simple and flexible and is preferred for smaller roofs (e. g. high-rise buildings). See Figure 1

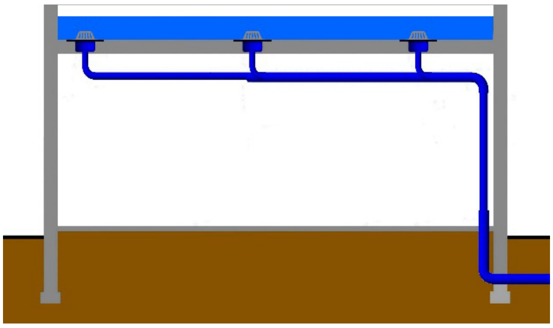

Figure 1: Rainwater storage on flat roof with siphonic roof drainage

Low-Sloped Roof with Siphonic Roof Drainage

With this construction, an area of the valley gutter is used as retention space. The lightweight roof construction requires reinforcement in the valley area. Roof dimensions, roof slope, and the water depth then create the retention quantity. The calculation can easily be executed with a small Excel program (please request from the author). This simple concept makes SRD particularly appealing. The construction is appropriate for large roof surfaces. See Figure 2

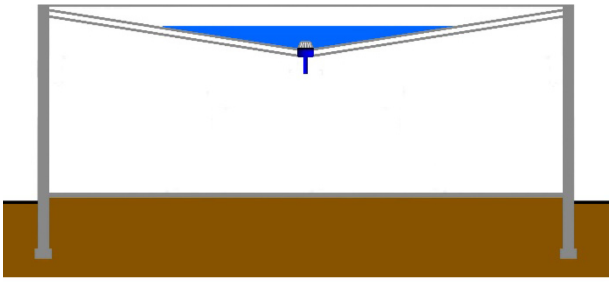

Figure 2: Rainwater storage on low sloped roof with siphonic roof drainage

To increase rainwater retention, Siphonic Roof Drainage is often combined with:

- Percolation box system
- Retention Box System
- Rainwater Storage Tanks
- Green Roofs

Percolation Box System

This method is not appropriate at every construction site. Rainwater cannot be contaminated, and the ground needs to be susceptible to percolation. Furthermore, suitable plots need to be available. The percolation facilities need to be checked, maintained, and cleaned regularly. See Figure 3

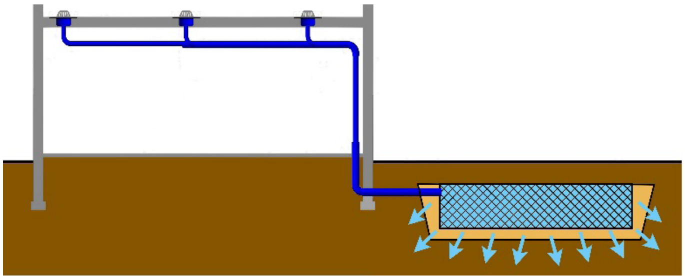

Figure 3: Siphonic roof drainage combined with buried rainwater percolation system

Retention Box System

Retention systems require space outside of the building. If there is no natural slope, pumps are needed to channel the rainwater into the sewer system. Retention systems and pumps mean additional technical equipment, which requires regular monitoring and maintenance. See Figure 4

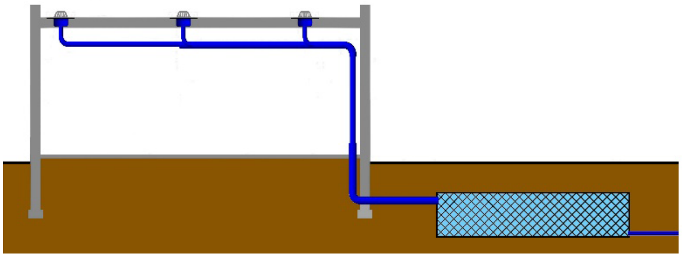

Figure 4: Siphonic roof drainage combined with buried rainwater retention system

Rainwater Storage Tanks

Storage tanks require space, either in the building or outside. For reuse of the rainwater or for discharging it into the sewer system, additional equipment is necessary (pipes, controls, pumps, etc.) which need to be monitored and maintained regularly. See Figure 5

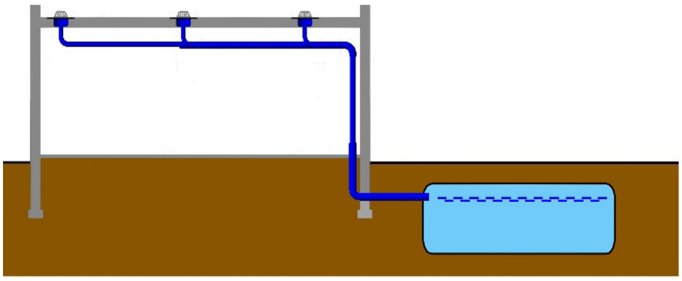

Figure 5: Combination of Siphonic roof drainage with buried rainwater storage

Summary

Flooding in cities can be mitigated by retention of rainwater on the roof. Especially suited for this purpose are roofs with siphonic roof drainage. Due to short-term storage of rain on the roof, no additional plots nor tanks, pumps or other equipment is needed. Additional roof loads - as required with green roofs - do not have to be considered. Retention combined with SRD has "few parts". This means low construction costs, low maintenance and repair costs, low risk of failure. This system is flexible and clear and can easily be adapted to the different precipitation zones.

Siphonic Roof Drainage does not pose a threat to the settlement of dangerous mosquitoes such as ditches, ponds and artificial swamps. Siphonic Roof Drainage is an important part of the Sponge City concept.

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Feasibility Analysis of Solar Power in a Manufacturing Plant

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A typical manufacturing plant has multiple processes like- casting, moulding, assembling, repairing, testing, processing, packaging, storing, etc. These processes consume both electrical and heat energy alongside a large quantity of diesel for power generation. Naturally, companies that use a lot of energy tend to have an adverse effect on the environment. With issues of climate change in the spotlight, companies today are taking cognizance of the impact that their activities have on the environment. Since the consumers are aware of the global concerns of increasing GHG emissions and global warming, they too prefer to do business with the "environmentally responsible companies". Owing to the fact that the companies strive hard to be ahead of the competition, they look at this consumer concern as an opportunity to serve the market and also act conscientiously towards the environment.

In India, the Confederation of Indian Industries (CII) has developed the Green Company Rating System as an initiative that aims to encourage Indian Industries to employ clean energy as well as to inspire companies to implement sustainable supply chain processes. CII basically evaluates how Green a company is. Accordingly, companies may be certified as "Green Companies" provided they take appropriate measures to offset their GHG emissions and meet their energy requirements through generation of green (e.g. solar) energy. Besides the benefit of reduction in energy purchase from the grid, the Green Company certification can enhance a company's global competitiveness, especially in the aspect of ecological sustainability.

The following case study was carried out at the manufacturing plant of a major firm in the household appliance sector. The firm wishes to attain a Green Company certification for its manufacturing plant located in Goa. It wishes to deploy solar energy profitably which requires selecting the appropriate business model. The period of the study spanned from January 2018 to June 2018. Its objective was to ascertain the feasibility of generating solar power within the plant as part of the company's larger initiative to enhance its standing in the Green Company Rating System set by CII.

The firm is a manufacturing plant located in Verna Industrial Area in the Southern part of Goa. The state of Goa encompasses an area of 3702 sq km. It lies between the latitudes 14°53’54” N and 15°40’00” N and longitude 73°44’33” E and 74°20’13” E. Goa features a tropical monsoon climate due to which it is hot and humid for most of the year. The month of May is usually the hottest seeing daytime temperatures of over 35°C coupled with high humidity. The monsoon period is from June to September, the post monsoon period is from October to January and the period of February to May is considered to be fair weather.

Green Milestones

The plant has taken up some green measures in its everyday operations as a part of its initiative to reduce its negative impact on the environment. Many of the components have been changed in terms of design and material consumption to reduce the energy and resource intensity of the production process.

The paint shop in the plant, for example, runs on LPG and makes use of powder coating technique. This avoids the release of VOC that accompany conventional liquid coatings. Similarly, freight movement has been optimized by deploying large carriers instead of mini trucks for distribution to nearby regions. This has achieved savings on diesel consumption and reduced GHG emissions. The plant has also laid down plans for a rain water harvesting system.

Challenges faced for conducting the study

As the plant was regular in its evaluations and audits, lots of data was being recorded at various points in the production process. However, the format of data recording was aligned with monitoring production rather than auditing the energy consumption. Hence data from several different sources needed to be gathered and assimilated as per the requirements of the study. Furthermore, some administrative roadblocks were faced in executing activities in parallel with production, as the green project related activities are considered secondary or ancillary to the primary production process. Finally, the continuous rainfall in Goa from June to September, means that solar production is very low during this period

Findings

Power consumption trend and power cost was studied from the previous electricity bills. Power tariff history of Goa was also studied. The electricity demand and consumption pattern for the manufacturing plant was studied and evaluated. The feasibility study involved Technical, Legal and Financial feasibility analysis.

It was observed that the power consumption and the power cost per unit was increasing every year. Solar rooftop installation was sought to not only abate the power cost, but also bring down the cost of diesel generator. The figure below is a comparative assessment for electricity charges in the plant before and after proposed solar solution.

Grid Electricity				
		Without Solar	**With Solar**	
fix charges	**Demand Charges**	250	250	
fix charges	**Meter Rent**	1000	1000	
variable charges	**Energy charges Day**	4.5	3.5	
variable charges	**Energy charges peak**	5.4	5.16	
variable charges	**Energy charges night**	4.05	3.87	
variable charges	**FPPCA Charges**	0.7	0	
variable charges	**Electricity Duty**	0.7	0	Power Cost Difference
variable charges	**Power Factor Incentive**	-0.255	0	
Total Variable	Day Time	5.645	3.5	-2.145 per KWH

DIESEL Generator Electricity.				
DG	**KWH generation**			DG cost Difference
1010kva	Power Generation Charg	21.5	3.5	-18.0 per KWH

Figure 1: Electricity charges before and after proposed PV installation

Results and discussions

In general, an industrial shed roof is tilted. In the case of the Goa manufacturing plant, the roof shed is oriented towards the North-South direction and the tilt of the roof is 15 degrees which matches the Latitude of the place (ideal for solar installation). Available shade free rooftop space is 20,000 sq. meters. The capacity of solar power can reach up to 1.8 MW as per the sanction load but practically only 1.5 MW is possible due to the rooftop space. It was observed that 57% of the power is consumed during daytime which is close to 38 Lac kWh in a year. It can be estimated from the CUF formula (taking 0.165 CUF) that 14,50,000 kWh can be generated per 1MW capacity per year. 62% of the power demand can be met through Solar as a 1.5 MW solar plant will generate around 21.75 Lac kWh/year.

Goa State Solar Policy 2017 has allowed all the Industries (large prosumer) to go for net metering connection. Due to this provision the plant can feed excess power generated to the Grid. However, when solar is incorporated in the energy mix in industries that have high power consumption, most of the power coming from solar is consumed and nothing is left to feed the grid.

Other alternate energy sources can be identified to substitute conventional fuel in the plant, for example, LPG consumption in paint shop can be reduced by switching to bio gas.

Firm's perspective: OPEX or CAPEX?

Business is all about getting a return on investment. When comparing between the two solar models CAPEX and OPEX, OPEX is preferable as there is a fixed tariff at which the solar power is sold to the plant. Additionally, the responsibility of O&M of the solar installations lies solely with the system installers. By contrast, a CAPEX investment is less attractive as the RoI on solar generation is not high. But we must refrain from discarding the feasibility of a solar plant from a strictly financially perspective. In-house generation of solar power must be seen as a golden opportunity for large manufacturing plants as it allows them to achieve a green image and increase their global market competitiveness. As the bigger players are turning to solar, it is setting a benchmark for smaller enterprises to become more responsible towards the environment and serve the market requirements.

The above article is based on the author's Internship report, submitted in 2018 to TERI School of Advanced Studies.

Artificial Intelligence – The fillip that Clean Energy Needs

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On 25th November 2018, AlphaFold, DeepMind's Artificial Intelligence (AI) won CASP13 Protein Folding Competition at the international conference in Cancun, Mexico. DeepMind is the premier AI research company of the Alphabet group. On their website they state: "From climate change to the need for radically improved healthcare, too many problems suffer from painfully slow progress, their complexity overwhelming our ability to find solutions. With AI as a multiplier for human ingenuity, those solutions will come into reach." Their success and vision are an indication of where the technological development in the Renewable Energy (RE) and Energy Efficiency (EE) sector may be headed.

What is so special about AI?

The primary advantage of AI is its potential to supersede our present physical understanding of complicated phenomena. To illustrate this, we may consider the example of soiling loss in solar panels. Soiling as a phenomenon is not well understood and there is no accepted theoretical formulation that can provide acceptable predictions of the reduction in power output from panels due to soiling. One of the reasons for this is that soiling is heavily dependent on local conditions and the number of possible parameters that may have a significant effect on the power output could be many (nature of soiling residue, interaction of residue with panel coating, wind effects, tilt, gravity, cleaning frequency, etc.) However, an artificial Neural Network based AI system which monitors all these parameters, can absorb these inputs much like stimuli and over time train itself to predict the panel output accurately. The underlying method of arriving at a solution does not involve mathematics or physics, rather the development of an intuitive idea of the "weightage" to be assigned to the values of the various parameters in determining their effect on the output. This can be understood akin to a shooter's ability to accurately strike a moving target despite not using any theory or calculation related to projectile motion. The ability is in fact developed through repeated practice and attainment of muscle memory.

An ANN based system can likewise be trained to recognize patterns even in solar irradiation under the influence of clouds with a high degree of accuracy. A well-trained AI only requires input in the form of measurements of macro parameters such as temperature, humidity, date and time of day, data from the meteorological department to make reliable predictions. This obviates the need for robust mathematical models or intensive computations which will allow predictions to be made in real-time. Hence the AI is effective in taking highly complex data containing a large number of poorly understood parameters and yet providing meaningful and accurate predictions.

Another task that AIs can perform very well is optimization and control. AI can incorporate optimization techniques that are inspired by the passing down of the genetic traits among biological populations, esoterically referred to as Genetic Algorithms (GA). This can be utilized in the creation of a futuristic smart grid with a central AI power flow controller. The functioning of the controller can be envisaged in the following way. Every possible method of power flow control in such a grid can be thought equivalent to a trait within a biological population.

Let's assume, for example two very simple methods of power flow control, the switching off of refrigerators during cold winter nights and reducing the brightness of screen displays when no viewer is detected. Ideally both forms of control have benefits but the first one may not be advisable in all cases. Hence the controller AI will evolve over time to have the right mix of these two "traits" for an optimized (fitter) energy efficient solution. On a limited nonetheless impressive scale, a similar power flow optimization was carried out on Google's supercomputer servers by their AI which was developed by DeepMind (https://deepmind.com/blog/deepmind-ai-reduces-google-data-centre-cooling-bill-40/). Along similar lines, it is not too far-fetched to imagine a Solar powered charging network for electric buses that optimizes both the energy and availability aspects of the public transport system simultaneously.

How can such AI's be developed?

AI's, at the end of the day, are man-made tools. They can be trained to become what are known as Expert Systems (ES). A solar consulting firm for example can use its data from past projects as inputs to train the AI system to assist in decision making regarding site selection, plant layout etc. Initially, the AI is fed the input parameters and made to provide an output. The output is evaluated by the engineers and the AI is retrained on the same data if the output is not satisfactory. Otherwise it is fed new data from a different project with different parameters. Once trained to satisfaction, the AI can provide quick and optimized solutions for the engineering parameters such as site selection, panel array structure, electrical networking of the arrays, etc. This will greatly reduce the time and effort spent on the engineering of the project itself. The supervised training of AI requires knowledge and understanding on the part of the human supervisors feeding the input and evaluating the output. Meanwhile the trained AI will reflect the combined knowledge of the past projects it was trained on and will be an apt representation of the firm's engineering methodology.

What are the risks involved?

An AI based systems is an intuitive rather than a computational device. Hence its intuition may be incorrect. But the AI is very resistant to discrepancies in the input data which may be introduced by human error. Also, inaccuracies can be reduced by further training. Furthermore, the AI is not susceptible to noise in the data and can successfully iron out less significant parameters and small inaccuracies in the data. Nonetheless, the AI systems can be susceptible to cyber threats which can corrupt its developed intuition. Consequently, cyber protection will need greater investment in order to protect the firm's greatest asset.

Conclusions

The RE and EE sectors are at a stage which allows them to be receptive to quick upgrades in technology and practice. Incorporating Artificial Intelligence, into their engineering and deployment would add to both their efficacy and appeal. This is especially so as AI systems are well suited to deal with ultra-complex, multi-parameter problems prevalent in renewable energy engineering, complete theoretical solutions for which may not be feasible. Adoption of AI can accelerate the shift to clean energy and prove crucial to the protection of the environment and ensure sustainability of our energy systems in the long run.

The article above is an invited guest article.

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