



December 2021

**EU Tech Chamber**  
**White Paper on Decentralized Energy Systems**





# EXECUTIVE SUMMARY

Renewable energies are crucial to resolve two major global challenges and so to meet the objectives of the SDGs and Paris Agreement: Firstly, to effectively meet a growing energy demand and secondly, to decarbonize the production and use of energy.

More importantly, energy development concerns not only the development of renewable energies but also the shift from centralized to decentralized and off-grid clean energy systems (DES). The future of distributed power generation can be 100% renewable provided we opt for a technology open approach. Highest additional potentials can be realized with the expansion of all existing types of renewables and to include more high altitude wind; that offers the possibility to produce baseload energy at an affordable cost even in remote rural areas as well. This combined with unprecedented global collaboration holds the potential to reach clean air for all.

The global energy transition, named Digital Green Shift (DGS), is shaped by the five “D” s: Deregulation, Decarbonization, Decentralization, Digitization, and Democratization. With this the development of DES has become a core part of any energy and economic strategies adopted worldwide driving the progress towards a highly sustainable and healthy future. The increasing proportion of decentralised electricity generation in supply mixes means that there are many more actors playing important roles in energy systems, leading also to more needs for zones to test collaborative innovation. It also gives more power to the people who become owners and producers of clean energy. These new dynamics complicate the tasks of authorities accountable for ensuring adequate, clean, and affordable electricity for society.

This report has been prepared by the Energy Council of the European Technology Chamber (EUTEC) to showcase key areas where DES affects our economies and lives as well as to present 10 key recommendations on how to make the energy transition a reality with the better technology option: DES!



**With great technology comes great responsibility.**  
**Technology Obliges!**

The European Technology Chamber is a registered NGO, which enables European businesses to use their technologies for the benefit of Europe and mankind. The EUTEC Chamber has three major goals and believes that technology is the answer to reach those.



**Competitiveness**

Strengthen Europe's competitiveness and transformation capabilities in its Global positioning



**Sustainability**

Leverage innovation, key technologies and business opportunities to achieve 17 UNSDGs



**Growth**

Build bridges to international markets and establish partnership for an inclusive growth







## About Energy Council

***Envisions a future where everyone should have access to affordable, reliable, sustainable & modern energy, technologies & services by 2030.***

Access to clean energy is a pre-requisite of human development. Energy is needed for individual survival, it is important for the provision for the provision of social services such as education and health and a critical input all economics sectors from household production or farming, to industry. The wealth and development status of a nation and its inhabitants is closely correlated to the type and extent of access to energy. The more ready usable energy and the more efficient energy converting technologies are available, the better are the conditions for development of individuals, household, communities, the society and its economy. Thus improving access to energy is a continuous challenge for governments and development organizations.



### Competitiveness Support

Making European companies more attractive to businesses & partners in energy sector by increasing their innovation capabilities.



### Expansion Support

Supporting European companies to create and to access international energy markets by business support and know-how transfer.



### Impact Projects

Empowering businesses in the energy sector by realising local impact through the formation of international EU-linked business & tech partnerships via matchmaking.



# METHODOLOGY

## EU Tech Chamber White Paper


An EUTEC White Paper serves as an informational document to share knowledge, foster exchange and collaboration, and create value for our advocates and the larger EUTEC community from society to businesses, from industry professionals to technological innovators.

Sharing technology-driven solutions and methods to help solve some of our most challenging questions on how we can improve our lives, providing insights from engineers, experts, and researchers.

A White Paper is carefully curated in collaboration with EUTEC advocates, supporters and contributors who share EUTEC's vision and values and is published by EUTEC Sections for educational and knowledge sharing purposes.



**With great technology comes great responsibility.  
Technology Obliges!**



# 10 RECOMMENDATIONS on Decentralized Energy Systems: An essential Path Way to Energy Transition





## 10 RECOMMENDATIONS

**1. Affordability through Competition :** By making the energy retail market truly competitive. This will include offering customers and end-users a simple method of switching to more energy cost-effective energy tariffs and testing automatically switching consumers to fairer deals to tackle "loyalty penalties".

**2. Sustainability through Decarbonization and more:** The core for starting new development trends could be to orientate the process of development more towards existing and future demands and to meet the needs of human beings in all societies with a minimum increase in entropy of the planet. Substitution of exhaustible energy sources with the renewable resources would mean decarbonization and it is also a basis for sustainable development.

**3. Energy Availability through Abundance of Renewables:** The future of distributed power generation can be 100% renewable provided we opt for a technology open approach. Highest additional potentials can be realized with all sources of renewables including high altitude wind energy generation and solar-thermal power generation technologies besides using huge amounts of unused areas geographically through with the support of governments in order to achieve "Net Zero" by 2050.

**4. Decoupling of Energy and Development:** Rapid decrease in energy intensity has been considered as an important strategy in industrialized and developing countries. Fossil fuels constituted more than 80% of primary energy consumption in 2020. Therefore, further decrease in energy intensity is associated with reduction of fossil fuel consumption which has resulted in less emission of local pollutants and greenhouse gases (GHGs).

**5. Deregulation:** Energy reforms play an essential role in technological change as they aim to contribute to an open market: costs reduction, competitiveness, and technology development. Over the last three decades, national and regional governments have strived to implement deregulation in the energy sector, reduce prices of commodities like electricity and enhance competitiveness in the industry, and averting the challenges brought about by regulation.



## 10 RECOMMENDATIONS

**6. Empowerment of SMEs & Non-Governmental Organizations :** Promotion of SMEs in the economic sector together with the support of NGOs at the society are important strategies that shall enable nations to resolve challenges of development, poverty and achieving a high quality of life.

**7. Digitization and Digital Economy :** Digitalization and technology are inseparable, digitalization is transforming energy transition like Artificial Intelligence (AI) which aims to create new business opportunities and increase the robustness, efficiency and benefits of the targeted professional activities. There has also been reduced carbon emissions as a result. Organizations in renewable energy are now employing innovative solutions for better efficiency and to optimize portfolios derived from advanced asset management.

**8. Democratization of Energy and Shared Economy :** To bridge the gap between local production and local usage, seasonal storage is a good technology. This can be done with a variety of technologies, but more and more healthy hydrogen is playing an important role in the energy mix. Local legislation is slowing down the introductions of various technological concept to scale up artificially. This reduces the rate at which more and more renewables can be integrated into the electricity grid.

**9. Circular Economy :** Circular economy is a concept that provides appropriate means for changing life style which would be compatible with the environment and it changes the production system to a non-linear and closed loop production system.

**10. Innovation:** Due to increased use of quantum computing and ultra-high-capacity-processors, the cost of these technologies will continue to go down, while the installed volumes will increase exponentially. This will lead to unprecedented local low cost of abundant solar and wind energy. This in turn brings the cost-of-renewable-electricity down, leading to a positive feedback loop of abundant healthy energy and clean air.



# 1. Affordability through Competition

With costs decreasing, renewable power production makes electrification an increasingly attractive option, enabling large scale phase out of fossil fuels in transport, heating and industry. And as electrification becomes increasingly feasible in more sectors, the energy system will also be able to utilise even more energy from renewable power sources.

In a fully renewable energy system, other technologies will play a role alongside solar and wind power. These technologies are at different stages of their development, however, with none of them being as mature as solar and wind energy are today. All have the potential to become competitive and scalable green solutions that can contribute significantly to a world fully powered by green energy. But it requires a well-orchestrated collaboration between governments and industry. And to this end, solar and wind energy experience is instructive.



Figure 1: Affordability through competition



## 2. Sustainability through Decarbonization and more



Figure 2: Sustainability through decarbonization and more [7]

Sustainability is a terminology that means the needs of a generation is met without endangering the resources that would enable meeting the needs of the future generation. Sustainability is, therefore, a concept that interlinks three elements of life including economy, society and the environment.

It was the last decade of the 20th century that the human and society as a whole understood that the capacity of the environment and eco-system is limited. It was realized that availability of natural resources and the capacity of eco-system to absorb the wastes and GHGs were limited. Hence, development of economy and the society based on the concept of accelerated supply of goods and services at any price was conceived as impossible.

On the contrary, demand oriented development of society has been conceived as an important change in the concept of economic and social development which would mean production of quality goods and services based on the needs of human being. It would also mean that conception of energy would be different from a commodity. Energy carriers were considered as commodities that were traded in the market. But the concept of demand oriented development considers energy as a utility services which is different than just a commodity. Energy is needed to acquire a service, such as maintaining comfort temperature, comfortable light, motive power. Energy services may be acquired from the environment rather than from natural exhaustible resources. Heating or cooling for maintaining comfort temperature or motive power could be obtained from renewable sources such as solar, wind, hydro power, biomass, etc. The core conception of new trend of development could be organizing the process of development according to the demand orientation and meeting the needs of human being in all societies with minimum increase in entropy of the planet.

Further development of developing countries, specially African countries, should follow a path of sustainable development and it should necessarily be accompanied with decarbonization. Decarbonization and substitution of exhaustible fossil fuels in both industrialized and developing countries should be realized as quickly as possible because the capacity of the planet is reaching its boundaries very rapidly. For this reason, both industrialized and developing countries have no other alternative unless to work together for decarbonization in all countries and to implement the concept of demand orientated development for achieving high quality of life in all nations.

### 3. Energy Availability through Abundance of Renewables

The easiest way to reach 100% renewable distributed power, is a cluster generation of energy most especially at the end user's side. An efficient application of wind and solar energy is abundant enough to take care of this cluster demand.



Figure 3: Energy availability through abundant of renewables [7]

Abundant solar and wind powers are available everywhere and complementary, making them ideal to power households and transport. Harvesting their energy together is always better than alone. To maximize the synergies between locally produced renewable energy, rather than trying to generate and consume “energy” at household level, it is better to do this at community level. It is economical to use different technologies suitable to the terrain. The alleviation of lifestyle would lead to “buy-in” from citizens, industries and governments for a faster uptake of these technologies.

The healthy energy shift to abundant renewables & healthy hydrogen (i.e. hydrogen produced with renewable energy that is healthy for humans and for the planet, such as abundant wind and solar) should become the “Principle Goal” besides distributed energy generation and supply the same through “Micro/Mini Grid” on the top of “energy efficiency” & “holistic thinking.”



## 4. Decoupling of Energy and Development



Figure 4: Decoupling of energy and development

Demand for energy increased exponentially in the 20th century and the slope of growth was high in the 3 decades upon end of 2nd world war. The high growth rate of energy consumption was associated with economic development in industrialized countries. There was a strong positive correlation between GDP and energy consumption. But the 1967 war between Israel and Arab countries and the strong position of Organization of Petroleum Exporting Countries (OPEC) in the world market in early 1970s led to fourfold increase in the world energy prices in 1973, that has initiated deep changes in approaching energy as a commodity. Energy security and enhancing domestic energy production became an important energy challenge in industrialized countries and they established the International Energy Agency (IEA) and tried to develop a common strategy among 24 western industrialized countries to combat volatilities in the energy markets.

An important outcome of energy policy review in industrialized countries was the improvement of energy efficiency and implementation of structural changes which was accompanied with application of energy efficient technologies. Improvement in energy efficiencies were identified as robust step towards sustainable energy securities and improving the total productivity of the whole economy. Structural changes in the social and economic system and intensive application of energy efficient systems and technologies reduced the energy consumption per unit of production and comfort temperature was achieved in the household sector with less final energy usage.

In the transport sector the share of public transportation in urban and intercity transport followed an increasing pattern. All efforts on improving the efficiencies were reflected in energy intensity of the whole economy which is indicated as energy intensity. Energy intensity is the amount of energy consumption per unit GDP at macro level. Reduction in energy intensity indicated more efficient usage of energy and decrease in the energy losses in economic and social processes and energy supply system.

## 5. Deregulation

Most studies acknowledge that deregulation is an effective method of achieving low electricity prices. However, the reduced prices can only be fulfilled if two conditions are met. First, lower power prices can be accomplished in the long run and not in the short term. After the changes are implemented, industry players must be transformed to accommodate the adjustments, taking a longer time than expected. Secondly, reduced electricity prices because of deregulation can be achieved if state regulators resolve institutional issues that hinder creating a competitive retail electricity market. Various studies have pointed out different factors that would hinder the creation of a competitive power market. First, the governments must develop strategies that would compensate industry players for the utilities for any profitable business they venture into. Previously, firms with monopolistic powers in the electricity sector were financially stable, so the production cost fluctuations were not significant enough to drive the entities out of business. However, the introduction of numerous entities increases competition and creates risks associated with unprofitable business pursuits. Therefore, the government should be willing to stipulate investors' measures in case of costly business ventures. In a state-regulated monopoly system, the entities would charge customers higher fees to recover any amount lost due to unprofitable businesses.

Deregulation can also be successful if regulators can improve and maintain the power grid's stability.



Figure 5: Deregulation



## 6. Empowerment of SMEs & Non – Governmental Organizations

A major element of sustainable development is social progress which involves people. Sustainable development is the subject of active involvement of people and individuals and desire of the communities for establishing a just and fair society where every individual can contribute freely to further development of the society and he/she can also enjoy the result of enhanced development. Sustainable growth of economy and social progress aims at establishing high quality of life at the community and it can be achieved if the whole process is conceived as common social goal.

At the micro level the economic activity of each individual achieves the highest efficiency when there is competition and no monopoly dominates the economic system which creates value-added in the society. The living condition of people depends on the availability of resources and affordable necessary commodities and services. Accessibility and affordability is subject to economic action with the highest efficiency and in an environment of perfect competition. Competition is a state of affair that can be achieved when many players and actors are involved in production and supply of needs of the society. State of perfect competition can be reached if the number of actors and suppliers tends towards infinity. Therefore, competition cannot be achieved with one large monopolistic firm. It requires rather many small and medium enterprises (SME) that take part in competition and supply chain of commodities and services to the society. Promotion of SMEs in the economic sector together with the support of NGOs at the society are important strategies that shall enable nations to confront challenges of development, poverty and achieving a high quality of life.



Figure 6 Empowerment of SMEs & Non government organization



## 7. Digitization and Digital Economy

The global energy landscape is rapidly evolving, in parallel, “Industry 4.0” technologies such as AI, Distributed Ledger / Blockchain Technology (DL/BT), Industrial Internet of Things (IoT) are rising as emerging enablers of the new industrial ecosystems. The first decades of the 21st century have witnessed the beginnings of a remarkable transitions in the world’s energy supply and distribution systems. The share of renewable and distributed energy resources are increasing globally. The most recent and significant impacts had been created by the COVID-19 which accelerate the transition to full Digital Economies. Digital Economy is a new form of economy established on advanced information and communication technologies such as AI, blockchain and 5G that aims to create next generation digital platforms and services. [UC1]

The global energy transition, named Digital Green Shift (DGS), is catalyzed and driven by the five “D”s: Deregulation, Decarbonization, Decentralization, Digitization, and Democratization. The rapid adoption of such emerging technologies, especially AI and DL/BT, is gaining momentum as a key enabler and highly disruptive technology which has very significant potential to impact or even disrupt various industrial sectors including the energy industry. Digitalization and Decarbonization of the energy industry are two game changing components of the Digital Green Shift which offers various new investment opportunities for future transactive energy systems and markets. Nevertheless, such newly opened territory of opportunities and technological advancement options enable new forms of Digital Sharing Economies (DSEs) such as Peer-to-Peer energy trading where surplus (mostly) solar energy is shared within the Local Energy Markets or even co-own the Distributed Energy Resources (DER) such as Wind, Solar Energy, Energy Storage (Electrical, Heat and Hydrogen Energy) using DL/BT. [UC2], [UC3], [UC4]



Figure 7 Digitization and Digital Economy

## 8. Democratization of Energy and Shared Economy

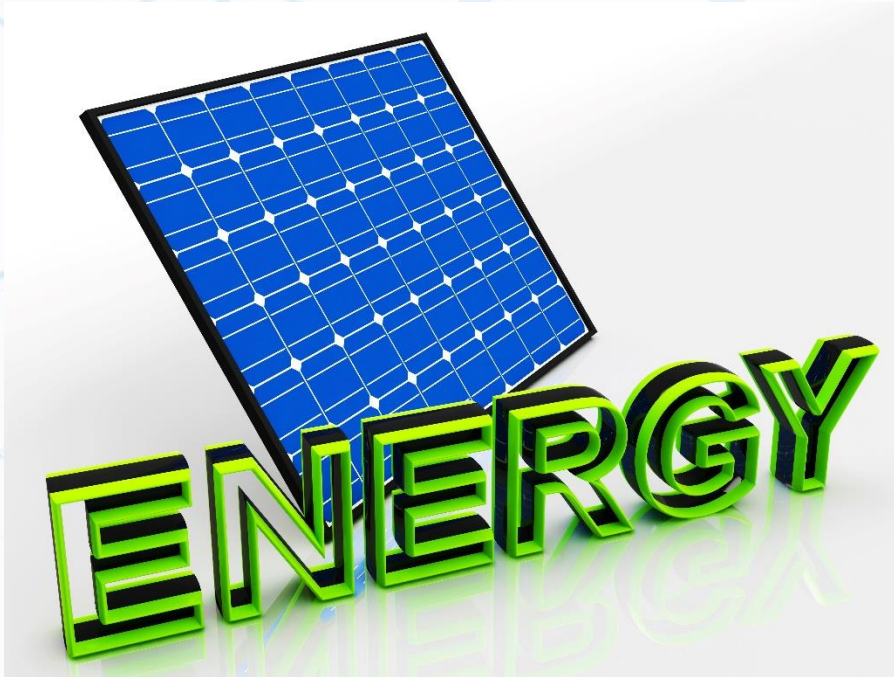


Figure 8: Democratization of energy and sharing economy

More and more citizens are co-owner of the renewable energy generation systems. They jointly own the windmill or solar installation. This leads to a democratization of energy. To reach a balance between production of green renewable energy and the demand, peak shaving with local storage a city or neighbour hood level is essential. Also sharing of the generated power in a local grid helps to keep the gap between production and usages of healthy energy. To bridge the gap between local production and local usage, seasonal storage is a good technology. This can be done with a variety of technologies, but more and more healthy hydrogen is playing an important role in the energy mix. At the moment the technical implementation has passed to prove of concept phase and it ready to scale up. Pending local legislation is slowing down the introductions of these solution artificially. This reduces the rate at which more and more renewables can be integrated into the electricity grid. The removal of tax and restrictions on sharing energy with neighbours, with decentral storage or decentral hydrogen generation will lead to more competition in the market place, increase the installation of more solar and wind at demographic prices. As this will prevent big upgrade investments in existing technologies, it should be a number one responsibility of policymakers to tackle this. Also adding more taxes on fossil fuels and using this to speed up seasonal storage needs will help to accelerate the global warming slow down.

## 9. Circular economy

Economic activity of human being started with linear production lines where raw materials flow through processes of physical and chemical changes to produce a final product. Chemical changes of material take place under specific thermodynamic conditions that should be established. Specific thermodynamic state is obtained with the help of utilities that include, among others, energy and water. As soon as the material undergoes a chemical reaction some part of utility is lost because the process is not reversible and unwanted elements of material is discharged as wastes.



Figure 9: Circular Economy

Physical changes of material are also subject to the availability of appropriate utilities. Some part of utilities is also lost as waste material or exhaust gases and sewage water. Physical and chemical changes require preparation of raw material and also post treatment of the product. In all these elements of production processes utilities are used where some part of them are lost as waste, sewage water and exhaust gases or heat. Linear activity of production system was the dominant technique up to the end of 20th century. Increased exploitation of raw materials and low efficiency of utilities and discharge of waste into the surrounding environment have been caused by rising demand for commodities and services which was based on the concept of supply oriented economic development. Discharge of huge amount of waste, polluted water, loss of energy and heat, greater emission of exhaust gases in the linear process of production has reached to a high level that scarcity of materials, water and natural resources has become a challenge for sustaining the production and meeting the needs for commodities and services. On the other hand, discharge of wastes to the environment is constrained by the absorptive capacity of environment and the eco-system. Such effects push human society and life to a corner where there shall be no opportunity to continue the life. It is a fundamental change in life style which can easily be observed in intelligent transport system, car sharing, environmentally friendly transport, less usage of materials that cannot be absorbed in natural environment. Recycling of materials, reuse of materials and commodities and increased efficiency are options that are considered seriously.



## 10. Innovation

According to studies from Tony Seba, the uptake of solar and wind, along with battery technologies, aluminium cells and other innovations will disrupt the energy markets, much in the same way the mobile phones have disrupted telecommunications. In fact, satellite broadband internet will revolutionise telecommunication by integration of the same with IoT and shared digital economy. Due to increased use of quantum computing and ultra-high-capacity-processors, the cost of these technologies will continue to go down, while the installed volumes will increase exponentially. This will lead to unprecedented local low cost of abundant solar and wind energy. This in turn brings the cost-of-renewable-electricity down, leading to a positive feedback loop of abundant healthy energy and clean air.

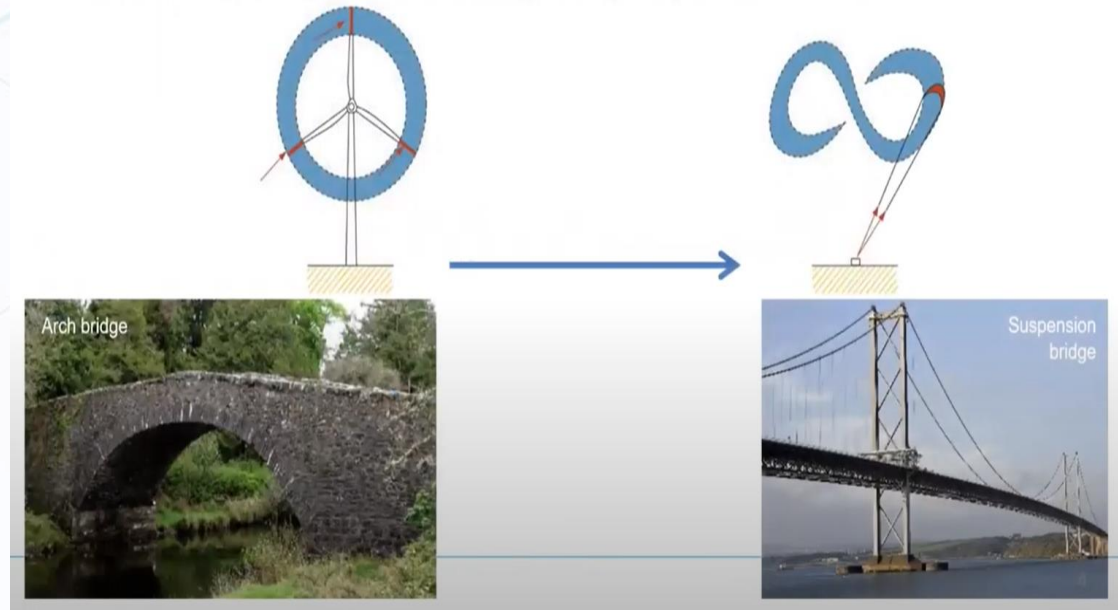


Figure 10: Innovation

For example with wind energy, a whole new sector of high-altitude wind technologies with autonomous large drones or autonomous little airplanes has the potential to boost the renewable energy generation. Up until now most renewable energy generation was intermittent thereby enforcing large scale storage solutions such as hydro, batteries, molten salt and healthy hydrogen.



# CONCLUSION





# CONCLUSION

To meet the objectives of the SDGs and Paris Agreement a stronger and faster shift from centralized to decentralized and off-grid clean energy systems will be needed. But the approach to follow goes beyond utilizing more and different types of renewable energy.

The already on-going global energy transition, named Digital Green Shift, is shaped by the five “D” s: Deregulation, Decarbonization, Decentralization, Digitization, and Democratization. Thanks to recent technology advances costs for RE investment and operations could be considerably decreased while increasing the efficiencies of the systems. Also because of lower levelized cost of electricity (LCOE) of solar PV, wind and other RE generation technologies as well as lower levelized cost of storage (LCoS) for the energy storage systems, meanwhile, a majority of the governments are demonstrating their willingness to support the Decarbonization and partially Decentralization of the energy systems by promoting renewable energy systems. The orchestration of governmental and industrial collaboration activities helps to create truly competitive markets which can trigger the willingness to pay for affordable RE solutions and switching to more cost-effective and greener energy tariffs and options; here with more deregulation ecosystem will be less monopolistic and also allow energy consumer and prosumers to opt for best offers from energy providers based on the rates that fits their needs and specialized product offerings.

Sustainable development of a society and an economy is about sustaining high quality of life in a society by the community and it can be achieved if the whole process is conceived as a common social goal. To speed up developments emerging Digitization's technologies like AI, Blockchain, IOTs, 5G, digital twinning have a promising potential to create new dimensions decouple energy demand from economic growth. Especially COVID 19 accelerated the rapid adoption of massive digitization shifts in various sectors including the energy industry. Digitization with Decarbonization processes is expected to provide new and undiscovered territories of future markets in fully digital economic ecosystems.





# CONTRIBUTED BY



**Dr. Umjit Cali**  
Associate Professor of Energy Informatics –  
(AI & Blockchain) at NTNU (Norway) &  
Cofounder, EnergyXchain LLC, USA



**Dr. Yadollah Saboohi**  
Prof at Sharif University of Technology –  
Dept. of Energy Engineering, Iran



**Bahman Hamedebarghi**  
CEO Nexus of Energy Efficiency &  
Environmental technologies (Germany)



**Alexandra Lybaert**  
Founder Little Lilly World  
Africa/Energy Chapter Advocate



**Marcus Wiemann**  
Director of EUTECH  
Africa/Energy Chapter



**Oyewole Olawole**  
Energy Sector Co-Ordinator at  
EUTECH



**Sanmi Fu Bo**  
Advocacy Manager



**Mohammad Abdullah Sajid**  
Graphic Designer



**Sharon Shang**  
Landing Coordinator

# SOURCES

- 1 UC1: Cali U, Kuzlu M, Pipattanasomporn M, Kempf J, Bai L (2021) *Digitalization of Power Markets and Systems Using Energy Informatics*. Springer Nature
- 2 UC2: Cali, U., & Çakir, O. (2021). *Novel Donation Sharing Mechanisms Under Smart Energy Cyber-Physical-Social System and DLT to Contend the Energy Poverty Problem*. *IEEE Access*, 9, 127037–127053.
- 3 UC3: Cali, U., Halden, U., Dyngre, M. F., & Bukvic-Schaefer, A.-S. (2021). *Blockchain-Enabled Equity Crowdfunding for Energy Storage Investments*. *2021 International Conference on Smart Energy Systems and Technologies (SEST)*, 1–6.
- 4 UC4: Halden, U., Cali, U., Dyngre, M. F., Stekli, J., & Bai, L. (2021). *DLT-based equity crowdfunding on the techno-economic feasibility of solar energy investments*. *Solar Energy*, 227, 137–150.
- 5 *Decentralized energy systems structuring a decarbonized future*. <https://www.eon.com/en/innovation/innovation-frontline/opinion/decentralised-energy-systems-structuring-a-decarbonised-future.html>
- 6 *Airborne wind energy* Roland Schmehl ISBN 9789811019463
- 7 *Clean Disruption of Energy and Transportation* – Tony Seba ISBN 0692210539

**Publisher** European Technology Chamber  
Wiesenstr. 8  
8008 Zurich  
+49 89 550 521 40  
info@eutec.org  
www.eutec.org

**Editors** EU Tech Chamber Editorial Team

**Photos & Illustrations** All photos, except where otherwise specified:  
<https://www.storyblocks.com/images>

**Year of Publication** 2021

This White Paper is presented solely for educational and knowledge sharing purposes. The authors and publishers are not offering it as professional services, legal, or investment advice. While best efforts have been made in preparing this document, the authors and publishers make no representations or warranties of any kind and assume no liabilities of any kind with respect to the accuracy or completeness of the contents and specifically disclaim any implied warranties of merchantability or fitness of use for a particular purpose.