Re-vitalizing Energy Transition in Touristic Islands

Energy Transition: from Roadmaps to implementation and results

Prof. Constantinos S. Psomopoulos, UniWA

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Introduction

The primary human response to protect the environment and ensure a sustainable existence on Earth is the already-existing global energy shift.

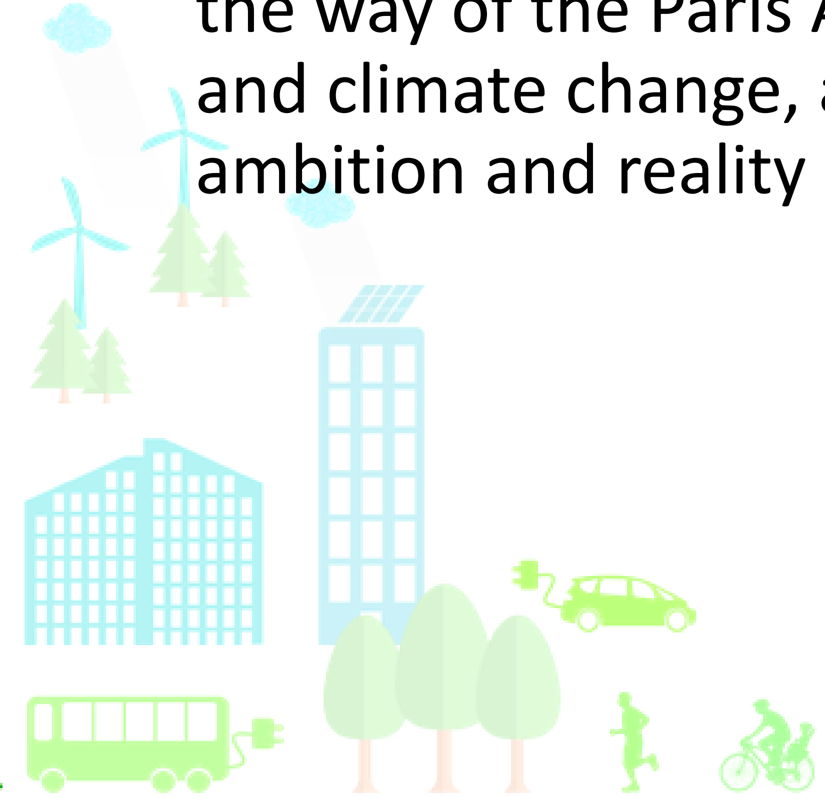
The Paris Agreement, which was signed at COP 21 and aims to keep global warming below 2 °C over pre-industrial levels, is the first step towards this energy transformation and the international commitment to halting climate change, expanding energy access, and preserving biodiversity.

Countries agreed to the United Nations' (UN) 17 Sustainable Development Goals (SDGs), which outline a strategy to improve both the earth and humankind by 2030, concurrently with the Paris Agreement.

SDG’s

Almost all of the SDGs have a cross-cutting objective: combating climate change.

Despite the clear international commitment, there are still obstacles in the way of the Paris Agreement's and the SDGs pertaining to energy and climate change, and there is still a big disconnect between ambition and reality in the fight against climate change.



While achieving these lofty objectives calls for dedication outside of the power industry, delivering decarbonisation across several industries through an integrated technique may serve as a legitimate remedy.

This is the fundamental notion behind the concept of Integrated Energy Systems, which are described as an integrated infrastructure for all energy carriers, with the electrical system serving as the backbone, in accordance with the ETIP SNET Vision 2050.

These systems are distinguished by a high degree of integration between all energy carrier networks, which is achieved by connecting gas and electrical networks, heating and cooling, and is backed by energy conversion and storage procedures.

By coordinating the planning and operation of energy systems across multiple energy carriers and achieving a more flexible, dependable, and efficient energy system overall, coupling different sectors indicates increasing efforts in a synergistic way.

large-scale electrification

A strong electrification scenario creates a number of challenges for the operation of a power system, which in principle would need additional flexibility, reinforcement, and new investments for the transmission and distribution networks.

Electrification is considered a valid cost-effective pathway for decarbonization of final energy consumption. This is mainly due to the fact that several technologies for converting renewable energy into electricity have recently become available at competitive prices such as PV and wind turbines. On the other hand, a large part of CO2 emissions in industries, transport, and buildings is not related to power sector but to end use of fossil fuels.

That is why, a large-scale electrification, characterized by the penetration of an electricity carrier produced by renewable technologies in building, transport, and industry sectors, represents a good pathway for decarbonization.

According to the International Renewable Energy Agency (IRENA) Renewable Energy Roadmap (REmap), the share of electricity in final energy consumption amounts to 20% today and will reach the percentages of 29%, 38%, and 49% in 2030, 2040, and 2050, respectively.

If electrification of final consumption is combined with the integration of energy sectors, decarbonization of energy demand would be reached through penetration of renewables in all energy end use sectors while also getting higher flexibility for the whole system by reducing the needs for reinforcing the existing network infrastructures.

Moreover, energy systems integration allows increasing efficiency in the energy resources use through exploiting synergies coming from the interplay of different energy carriers and reduction of renewable energy source curtailment.

In practice, for instance, in the case of excess electricity from RES, it can be converted into gas as hydrogen or synthetic methane through Power-to-Gas (PtG) technologies, stored and/or transported by existing gas infrastructures for immediate or later usage, or re-converted again into electricity when renewable electricity supply is insufficient to satisfy the loads.

On the other hand, PtH technologies combined with thermal storage can shift production of thermal energy when renewable electricity is in excess, thereby representing another option for reducing RES curtailment

Grids

The deployment of renewable technologies at a local level led to the switch from a “one-way” generation system mainly relying on a few large power plants connected to HV and EHV grids and located far from consumption areas to a “multi-directional” system, whose characterization and management are extremely complex.

In the traditional electricity system, the electricity produced in large power plants reaches the users – through the transmission and distribution networks – playing the passive role of energy consumers.

Grids

On the other hand, the energy model of DG mainly consists of a number of medium–small generation units (from a few tens/hundreds of kilowatts to a few megawatts) usually connected to distribution networks.

DG units are usually located close to the loads to satisfy and designed to exploit renewable sources spread throughout the territory and otherwise not usable through traditional large-size generation units.

Benefits

The benefits offered by this new energy model are different:

- increase of the efficiency of the electricity system thanks to the reduction of energy transport loss;
- increase of RES penetration levels and more rational use of energy; and
- optimization of the resources at local level and the local production chain.

According to REmap, the renewable energy share in power generation will more than double in 2030, reaching the value of 57% as compared to the current percentage of 25%, to arrive at values of 75% and 86% in 2040 and 2050, respectively.

Only in the case of PV systems, the REmap cases foresee that the annual solar PV additions will pass from the current value of 109GW/yr to 360GW/yr in 2050, and a similar situation is expected for wind source, for which the annual additions are expected to pass from the current value of 109GW/yr to 240GW/yr in 2050.

Reliability and stability issues are getting worse as intermittent renewable energy sources become more prevalent in electrical networks.

Finding new sources of auxiliary services, which are often supplied by large synchronous generators, is imperative in order to mitigate uncertainty, which jeopardises the equilibrium between generation and demand.

Promising flexibility possibilities for power networks through energy conversion and hydrogen storage are shown by energy systems integration, particularly the linkage of the gas and electricity sectors.

However, when PtG technologies are used during times of surplus power supply, there is no need to reduce the amount of renewable electricity generated or make extra expenditures in infrastructure for electricity transmission, distribution, or storage.

Active consumer

The development of the role of the energy consumer is a significant factor that is intimately tied to the changes impacting the energy sector.

The citizen has traditionally been a "passive" user, fulfilling the function of the consumer by using the energy generated centrally to satisfy their energy requirements.

On the other hand, the scenario that has been developing in recent years involves the rise of a new kind of "active" consumer who is more aware of their own energy pricing and usage and who is more sensitive to the use of "green" energy resources because of digitisation.

By using DG devices, end users may generate and utilise their own energy, store it, and then sell it back to the grid by taking advantage of the local RES; as a result, they go from being simple consumers to "prosumers."

The result is the emergence of the "self-consumption" concept, which holds that energy produced is consumed at the same location as it is consumed, both instantly and through storage systems, irrespective of the topics addressing the roles of a producer and a final consumer, so long as they function in the same appropriately defined and confined space and are fed by the same source.

Demand Response

Demand Response (DR) is another component that allows the end user to actively participate in the evolving energy landscape.

DR programs are defined as adjustments to end users' electricity consumption in response to fluctuations in energy prices over time or the provision of incentives intended to reduce electricity consumption during times when the wholesale market price is high or when issues with system reliability arise.

The definition given above states that the DR is an active consumer response to changes in energy prices or incentive payments.

When there is a high energy demand or low reserve margins, customers are encouraged to promptly adjust their power use through DR programs.

Energy price peaks are less likely to occur when energy consumption is reduced or modulated in accordance with market price trends.

In addition, DR services are a crucial tool for network managers to keep supply and demand in check and guarantee system dependability.

Therefore, in reaction to a price signal (originating from tariffs or directly from the electrical market) or in accordance with agreements signed with parties like aggregators and network operators, the end user may temporarily alter the power commitment.

It is crucial to emphasise that local DG units may also be regarded as a DR resource since they enable a decrease in energy withdrawal from the grid without influencing consumer load and absorption curves. Three major categories can be used to group the traditional actions that DR can take:

- lowering demand during system peak times;
- moving demand from peak to off-peak times, which results in a load shifting effect that levels the peaks and fills the valleys of the load curve;
- self-production or use of stored energy, which keeps the user's system's internal absorption profile unchanged but lowers the network's energy demand.

The Transition to Integrated Decentralised Energy Systems' Foundations

Storage of all kinds is essential to an integrated energy system that makes the most of the locally accessible energy resources economically.

By storing excess energy and delivering it when needed, energy storage can offer the energy system as a whole a number of services.

Energy storage systems

It can reduce RES's unpredictability, increasing the power system's flexibility and dependability.

One of the greatest technologies for short- and mid-term flexibility services, such peak shaving, spinning reserve, frequency management, etc., is battery energy storage systems.

When solar and wind energy penetration rates are high, long-term storage services, including seasonal storage, are required.

production, and bulk energy storage systems like mechanical storage facilities, electrochemical energy storage, or pumped hydro plants often supply them.

Digitalization

Digitalization is a key enabler for integrated decentralized energy systems by integrating innovative technologies in the electricity system through interoperable, standardized data architectures and related communication for achieving higher levels of efficiency.

Digitalization improves the observability of the power system for stable and secure operation in the presence of high shares of RES, enabling advanced planning, operation, protection, control, and automation of the energy systems, through the availability of real-time information that improves system balancing and resilience at all time scales in the case of any unforeseen and sudden event.

Information technologies such as artificial intelligence, big data management, and semantic data models will help operators make choices and optimise and automate procedures.

Service facilitation and complete integration of all energy system types will be achievable through digitisation.

Moreover, digitisation is also crucial to leverage the full potential of active consumers to contribute to the successful integration of RES in the electricity system.

The massive integration of smart meters and Home Energy Management Systems will allow the implementation of new business models and aggregation schemes (e.g. energy communities) that exploit the flexibility of the active consumers.

Smart mobility plays an important role in accelerating carbon neutral transition.

When supported by higher deployment of RES, it contributes withmultiple benefits to the sustainability of the transport system. In fact, electric vehicles are expected to play a primary role in the decentralized energy system and represent a driver for increasing RES integration in the buildings to meet their additional power demand.

By economically lowering CO_2 emissions, smart grids also aid in the energy transition. They lessen the demand for additional investments by maximising asset utilisation.

Additionally, they make it possible for renewable energy sources and new, effective technologies to proliferate, which lowers expenses and carbon emissions.

The capacity to provide real-time and monitoring control that enhances the electrical system stability, resilience, and security is another significant advantage of smart grids. Finally, they improve the quality of the electricity delivered by lowering technical and economic losses.

Another component of integrated energy systems is the efficient use of energy in buildings.

Furthermore, new buildings will typically be almost zero-energy and perhaps positive-energy due to active local energy generation (building-integrated generation) and energy efficiency measures (such as insulation and energy-efficient appliances).

local energy communities

Last but not least, the shift to a low- or even carbon-neutral energy system will progressively depend on local energy communities.

They offer a new paradigm where active prosumers and consumers are involved and actively participate in collective forms through citizen energy communities and renewable energy communities, particularly in the European setting.

Additionally, the idea of local integrated energy systems

—which have clearly defined boundaries and involve various energy technologies and carriers that can be integrated to maximise the synergies resulting from this interaction and improve the use of energy resources—

can be perfectly embodied by local energy communities.

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