FIRST LEGO LEAGUE CHALLENGE

Hydrogen, renewable and clean energy, artificial intelligence, energy consumption: what links?

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The IEA declares that most of the global CO2 emission reductions by 2030 will be delivered by technology already available in today's market. Artificial intelligence - AI - leverages computers and machines to mimic the problem-solving and decision-making capabilities of the human mind; something which can be applied in almost any context we can imagine. According to the European Union's Research and Innovation rapporteur, Annette Ekin, "AI can strengthen climate predictions, enable smarter decision-making for decarbonising industries from buildings to transport, and work out how to allocate renewable energy." One example of such advancement is by Google alums from DeepMind Technologies - a British artificial intelligence subsidiary of Alphabet Inc. They have used AI to manage temperature controls inside Google data centres, massively shrinking the company's electricity bill. They are now bringing this technology to regulate temperatures in power plants and industrial giants – in short, some of the dirtiest fuel users. However, as with any new technology, it is not as simple as it can at first sound. A 2018 World Economic Forum (WEF) report suggested that, as helpful as AI could be, it also "has the potential to accelerate environmental degradation with its use of power-intensive GPUs (graphics processing units) which are used to process diverse data simultaneously."

Using AI consumes a lot of energy – data centres crucial for machine learning and training AI systems demand abundant power. AI systems focus on enhancing the precision of results; with increasing accuracy comes more complex systems – which, in turn, require more energy. When renewable power is not available, then AI can be as detrimental as other energy-intensive polluters.

WEF concludes more investigation is necessary to large-scale and long-term deployment. But hope remains after a 2020 study on the role of artificial intelligence in achieving the Sustainable Development Goals. With support and regulatory oversight, AI was estimated to enable 93% of UN (United Nations) 17 SDG (Sustainable Development Goal) environmental targets – by speeding up existing solutions, facilitating development of low carbon buildings, and growth of smart cities.

In 2021, the EU funded the AI XAIDA project to characterise, detect and attribute extreme events using a new data-driven, impact-based approach. Novel AI techniques will be used to develop climate modelling, and shed light on event attribution, atmospheric dynamics and more. XAIDA hopes to study the effect of climate change on phenomena like cyclones and convective storms and provide tools to assess the causes of the environmental disasters that would deprive children in developing nations of clean water and food.

Machine learning, despite its shortcomings, presents an exciting and ever-expanding field, in the climate sector, as in many others. It can recommend optimal solar panel placements using satellites and create spatial monitoring for carbon sequestration.[1]

[1] Energy and Climate Intelligence Unit, Annie Moses, *Artificial intelligence in the battle against climate change*

The low-carbon transition will need AI to integrate a large increase in intermittent renewable energy while ensuring a stable grid

Supported by other emerging technologies, such as the internet of things (IoT), sensors, big data and distributed ledger technology, AI has the ability to unlock the vast potential of renewables

AI is far superior to humans when it comes to carrying out complex tasks at speed. Given that an energy grid is one of the most complex machines ever built and requires split-second decisions to be made in real time, AI algorithms are a perfect fit.

AI programs have been developed, such as IBM’s program for the US Department of Energy’s SunShot Initiative, which combine self-learning weather models, datasets of historical weather data, real-time measurement from local weather stations, sensor networks and cloud information derived from satellite imagery and sky cameras.

The result has been a 30% improvement in accuracy in solar forecasting, leading to gains on multiple fronts. “We found that improved solar forecasts decreased operational electricity generation costs, decreased start and shutdown costs of conventional generators, and reduced solar power curtailment,” says Hendrik Hamann, Distinguished Researcher and Chief Scientist for Geoinformatics at IBM. Forecasts of the base variables – wind speed and global horizontal irradiance, as well as the resulting power output – allows for a view on a range of time horizons, from minutes and hours ahead (for maintaining grid stability and dispatching resources) to day-ahead (optimizing plant availability), to several days ahead (scheduling maintenance).With increasingly larger data sets becoming available, predictions can now go far beyond the weather to train algorithms to predict more remarkable outcomes. For instance, how much additional power is used during a festive holiday, a large-scale international event, or how much altitude impacts a community’s energy use. For generators and energy traders, more accurate forecasting of variable renewable energy at shorter timescales allows them to better forecast their output and to bid in the wholesale and balancing markets. Through a grid-stability lens, with AI ensuring that the power grid operates at optimal load, grid operators can optimize the energy consumption of consumers. In the all-important flexibility jigsaw, the ability to understand consumers’ habits and actions creates greater flexibility in a smart grid because AI algorithms can make predictions about a building’s energy use 24 hours in advance, based on its experiences in the past. AI can predict and make energy storage management decisions by considering forecast demand, renewable energy generation, prices and network congestion, among other variables. Poor data, consumer mistrust and regulatory barriers could all prove problematic for the technology.In today’s digital age, concerns have emerged that relying on AI too much could leave energy networks vulnerable to cyber attacks.[2] Despite the fact that the epidemic has wrecked devastation on human civilization, it will enable a quick growth in renewable energy, which will contribute to long-term growth. The building of renewable infrastructures will help speed up the post-pandemic economic restoration. Building on a broad-based and distributed energy storage system will be an important way to ensuring energy supply security depending on the renewable-dominated system. AI technology, which were essential in combating the epidemic, will also aid in the future growth of energy by making it more clean, efficient, and intelligent. Future research should take numerous paths: new prospects in AI have continually emerged as a result of unique needs, energy efficiency, and savings, as well as reducing and eliminating the environmental load produced by electricity production, transmission, and distribution. It is possible to discuss sustainable energy options and their implications for energy in the event of a future pandemic.[3] Applying AI to energy efficiency techniques can deliver

[2] Renewable Energy Country Attractiveness Index (RECAI), Thierry Mortier, *Why artificial intelligence is a game-changer for renewable energy*

[3] Sharifi, A., Ahmadi, M. & Ala, A. *The impact of artificial intelligence and digital style on industry and energy post-COVID-19 pandemic.* 28, 46964–46984 (2021), Springer Nature Switzerland AG

results quickly. One opportunity for Europe is to better leverage the smart meters installed around the region with connected mobile applications that allow end-users to understand and manage their real-time energy usage. The Centre for IT Intelligent Energy Systems in Denmark has studied numerous AI applications that show massive efficiency impacts. AI could reduce the amount of energy used for wastewater treatment and the related greenhouse gas emissions, by roughly 40%, without sacrificing the targeted output. Smart meter data can feed into AI systems that intelligently guide energy demand schedules, resulting in lower-cost energy usage and avoidance of demand spikes and grid imbalances. Another opportunity is to encourage businesses and local governments to install AI-powered energy management systems better to manage space heating in buildings and other indoor spaces.[4]

The influence of Artificial Intelligence (AI) is rapidly increasing in all Engineering areas, but in particular in Renewable Energy Systems. Several interesting intelligent techniques have been developed for Renewable Energy Systems. There are many applications, such as Wind Turbine Control or Photovoltaic Panel and Power Electronics Control, that recent years have achieved a great improvement. Smart grid control and management are also very relevant fields for AI applications. Additionally, Hybrid renewable energy plants (such as wind/PV plants) with battery energy storage systems for providing ancillary services to the electricity grid are also of high interest, since control algorithms are important in order to optimize energy management services and offer different grid control applications. Another important research subject is the time series forecast in renewable energy systems. This is due to their stochastics behavior in many aspects as energy resources, energy consumption, system availability etc. Hydrogen based energy system is another relevant research topic due to its increasing importance as energy vector in Automotive.[5]

Renewable energy sources including hydro, solar, and wind have been the focus of extensive research due to the proliferation of energy demands and technological advancement. Wind energy is mostly harvested in coastal areas, and little work has been done on energy extraction from winds in a suburban environment. The fickle behavior of wind makes it a less attractive renewable energy source. However, an energy storage method may be added to store harvested wind energy.[6] The same could be done for hydroelectric or marine energy. Can the feasibility of extracting wind or marine energy that can in turn generate hydrogen energy in a suburban environment be evaluated using artificial intelligence techniques?

And if energy produced from hydrogen is so difficult to store, while energy produced from renewable sources, is stochastically volatile, can artificial intelligence help solve such problems? How? How much would its energy cost and carbon footprint be?

"The European Union has established a 'European Hydrogen Bank' of 2.3 billion; the cross-border Hydrogen Valley between FVG, Slovenia and Croatia has received 25 million, with a 72-month (5-year) lead time for implementation. The hydrogen produced, defined as 'green' because from renewable sources, will have to be 'at least' 5 thousand tons per year, of which 20% will have to be transported across the border. Thirty-four organizations were involved, respectively nine private entities from FVG and 17 from Slovenia and Croatia. Scientifically led by the University of Trieste for FVG, the University of Ljubljana for Slovenia, and the University of Rijeka for Croatia. Then there are many private entities involved; for Italy Area Science Park, Pittini, Danieli, Halo Indutry, Edison and many others; for Croatia it is worth mentioning ACI Marina and for Slovenia HSE, the Slovenian equivalent of ENEL. There remains, at the bottom, the disquiet of a dilemma: hydrogen is very expensive; extracting it consumes

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[4] EURACTIV

[5] Sustainability - Special Issue, *Artificial Intelligence for Renewable Energy Systems* (ISSN 2071-1050).

[6] Ali Javaid, Umer Javaid, Muhammad Sajid , Muhammad Rashid, Emad Uddin , Yasar Aya and AdeelWaqas, *Forecasting Hydrogen Production fromWind Energy in a Suburban Environment Using Machine Learning*, Energies 2022, 15, 8901.

more energy than is actually produced; and finally, yes, there are government and European incentives, but should they cease, industries will stop using it."

We wonder how these aspects are connected, what is the state of the art on the Italian territory and what are the possible futures related to these challenges.

We are curious to test whether it is practically feasible for us as students to develop a prototype of a system that takes advantage of artificial intelligence to perform small tasks (such as recognizing images and distinguishing waste from one another): if in our own small way we can reduce the energy impact related to simple actions (proper recycling of waste) through small tools that take advantage of AI, perhaps at the systemic level we can trust that others, with more relevant skills than ours, are able to create intelligent systems that know how to take full advantage of renewable energy, clean energy storage and consumption monitoring for a better future.