4 RES

the answer to increasing renewables share in the power generation

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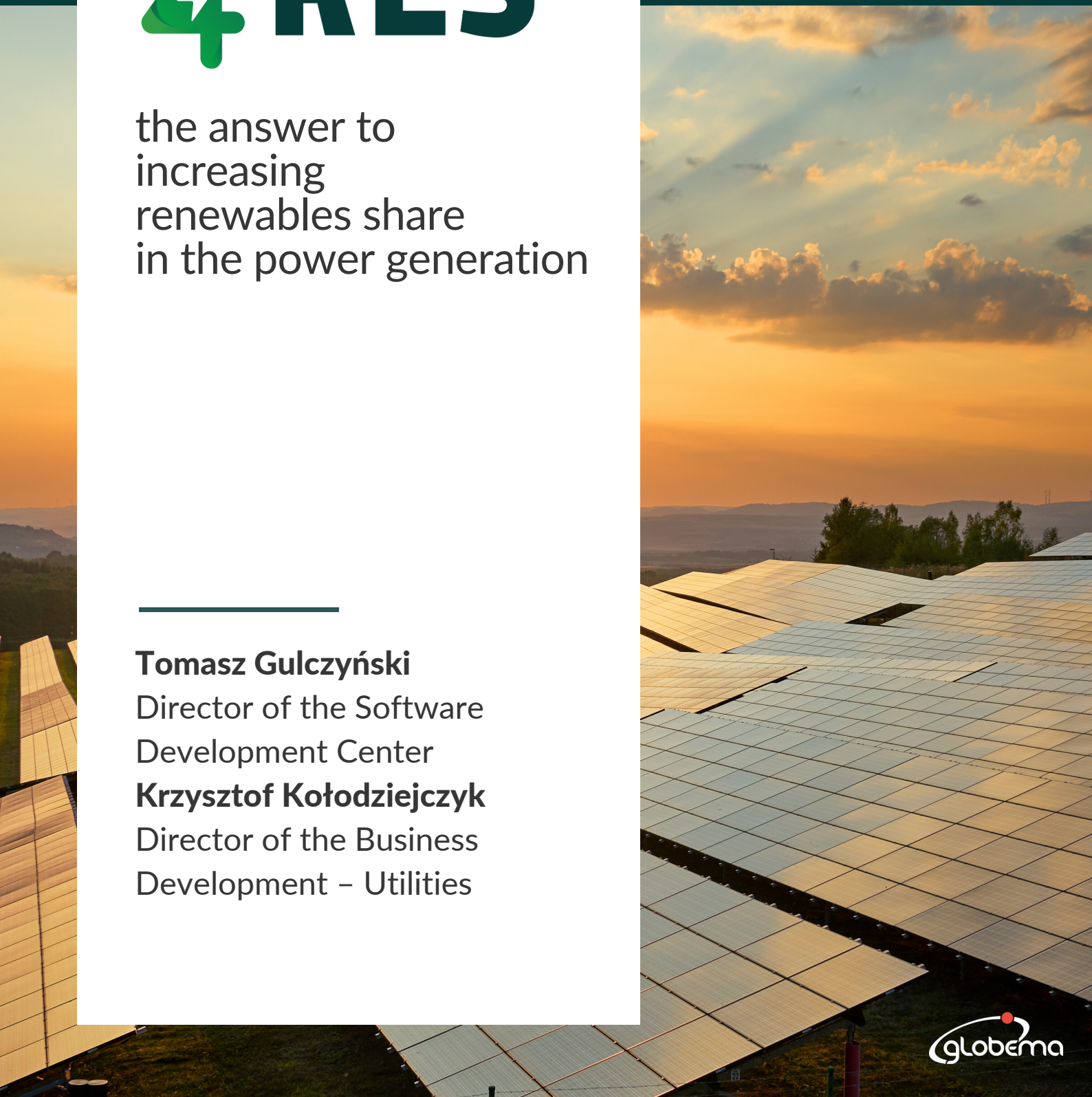

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Introduction

Nowadays, the systematic growth of electric energy obtained from renewable energy sources (RES) is common. Companies invest in large, industrial RES and there is a notable increase in the number of energy prosumers. Energy produced by prosumers is a typical distributed generation with low unit power. Production of energy from renewable resources, especially wind turbines and solar cells, is heavily dependent on weather conditions.

Currently, the instability of RES energy production is compensated by regulating reserves (a.k.a. frequency-response reserves) of conventional energy sources. Sudden fluctuations in the RES energy production rate caused by constant weather changes are dangerous for the stability of the energy system. This is why the accurate prediction of short-term and ultrashort-term RES production and its optimization in real-time is particularly important.

The prediction of RES energy production may include:

- **ultrashort-term** – a few hours ahead,
- **short-term –** several dozens of hours or a few days ahead,
- **medium-term –** several days ahead.

Ultrashort-term prediction is mostly used to control the energy production, storage and consumption facilities in order to balance the energy subsystem. Short-term prediction is used to plan energy system operations and support their share in the energy market. Planning operational and maintenance works in the energy system (such as maintenance shutdowns) is usually based on medium-term predictions.

The capabilities of RES energy production predictions are **limited by phenomena while transforming available primary energy into electrical energy**. Prediction quality depends on the energy's time horizon. Primary energy in the RES, particularly kinetic wind energy and solar energy, constantly fluctuates and usually changes in the horizon of several minutes to several dozens of minutes.

The most accurate predictions of energy production are estimated based on **NWPs (Numerical Weather Predictions)**. However, predictions that have acceptable accuracy are currently only available for horizons of a maximum several dozens of hours. This means that they can only be used for short-term and ultrashort-term predictions.

Additionally, since the predictions are estimated globally, they contain errors that appear on a local scale. **Errors in the final energy production prediction are many times larger than the NWP errors** because of the nonlinear relationship between weather conditions and energy production. This requires designing sophisticated prediction methods that use not only NWP data but also additional data such as the local conditions of an area, the current production, etc. This way, predictions can be corrected.

Prediction accuracy corrections can also be achieved by using complex prediction methods, dedicated weather forecasts, follow-up corrections of local measurement results, or integrating different types of sources into virtual power plants.

All these methods were used to create the 4RES system. It was developed by Globema's Research & Development Center as a result of two research projects about predicting energy production. The first project focused on individual predictions for specific renewable farm locations and mostly large wind installations. The second project studied small distributed energy systems (including consumer energy) widely dispersed on large areas (such as a country).

Both projects were conducted in collaboration with companies that manage renewables. Research for larger production units resulted in designing methods for **the local correction of weather forecasts**. It also allowed researchers to determine the profitability threshold of production predictions resulting from installed power.

Using hybrid methods of prediction resulted in prediction errors of **9-12%**, normalized by installed power. Aggregating several wind and solar farms into one virtual power plant (VPP) reduces errors to as low as **6%**.

Research for area-based predictions for distributed sources focused on **determining areas with similar weather conditions**. The idea is based on replacing many local forecasts with one, area-based weather forecast which can be used to schedule energy production with RES in a particular area. This method can be used for many, small power sources treated as a virtual power plant and one total volume on the energy market.

Analyses showed that despite the setback of weather forecast quality (caused by value averaging for the researched area), errors in area-based production predictions are still at the satisfactory level of 5-6%. This result shows that the area-based approach and virtual power plant concept allows precise predictions of hourly energy production over several days.

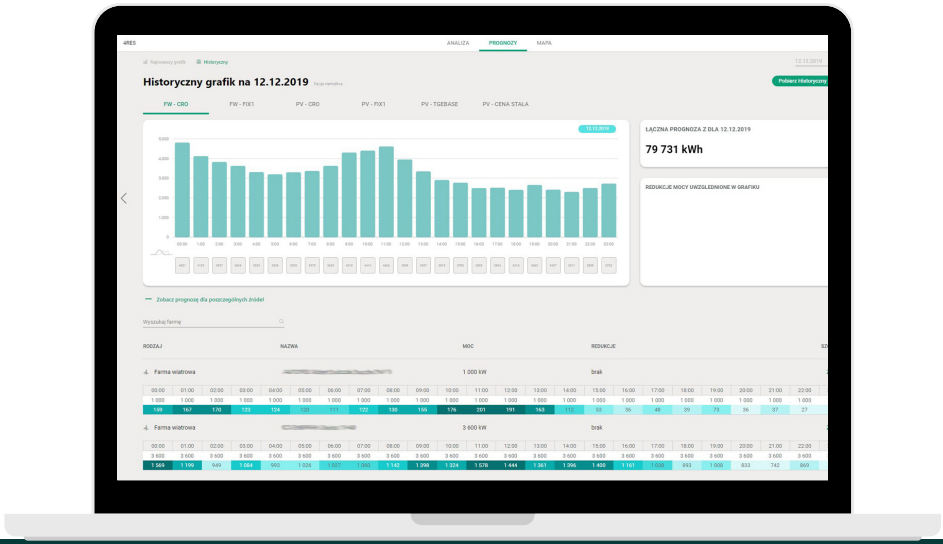
It's worth mentioning that an additional part of the research was about the **influence of energy production from distributed RES on energy networks** – specifically on **additional flows in the network's nodes**. In the future, these results may become a basis for local balancing. Today, they are used to evaluate networks and help avoid local overloading. We will talk about these issues in a separate article – we encourage you to read it, too!

4RES incorporates all of the research results. It was designed to serve companies that sell energy by providing energy production schedules. It also supports the optimal planning of maintenance windows for energy source owners and helps distribution systems operators predict energy flows in the network's main nodes from distributed sources.

How does 4RES work?

4RES consists of two components: computational engines and a business user application which allows editing operations for renewable energy sources and production schedules, as well as historical data analysis.

Computational engine modules are powered by historical data, data about the current production of particular sources, and weather data provided by **the Interdisciplinary Centre for Mathematical and Computational Modelling at the University of Warsaw**. Data is used to tune the initial prediction model based on **artificial intelligence (AI) and machine learning (ML) algorithms** and again at a later time to improve them. In the case of missing historical data, computational engines use physical models of the operations of RES.



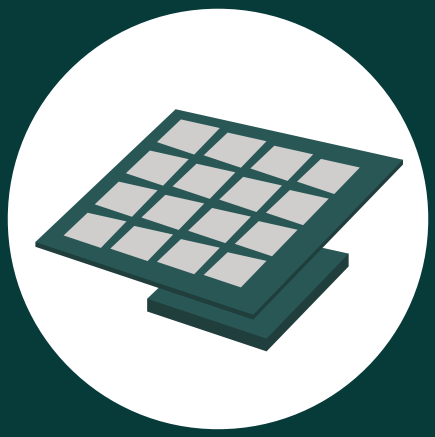
Weather forecast models are chosen depending on the type of energy source, installed power usage, and the territorial distribution to optimize prediction-making costs while preserving their quality. The resulting production prediction covers the time horizon from several hours up to 10 days ahead.

This solution implements the newest trends in the field of prediction by **integrating parallel prediction models considering the influence of many weather variables on energy production**.

Another important element of the system is gathering different types of historical data (energy production data, technology process data, maintenance data) for consideration in the following prediction periods.

Building virtual power plants and managing scheduling units that include many sources is crucial as well. Connecting different sources located in various places allows he operators to correct the prediction accuracy and lower fluctuations in the total energy production. Incorporating regulated sources or energy storage into VPPs can result in a desirable mix of energy. It improves energy efficiency and minimizes the unwanted influence of distributed generation on the network.

Separating computational engines from the rest of the solution allows systematic development without interfering in the user application and sharing scheduling services without the need to purchase the whole system license.



Functionalities of the business user application address the needs of energy producers, companies that sell energy, and network operators. The first group can use the application to **plan maintenance windows in a way that lowers the amount of loss resulting from a unit outage**. The second group can **automatically schedule production** based on current weather forecasts. Schedules can be **adjusted at any point based on expert knowledge** that hasn't been included in the system's model, such as planned maintenance or existing outages.

Historical data can be analyzed to detect deviations in production and predictions or measure error size and its financial impact. The analyses above and business agreements can be used to **create a future market strategy**.

Additionally, 4RES provides network operators with data about local energy production and **related further burden on network nodes,** considering even the smallest RES. This allows more efficient planning and managing of local network operations for medium and high voltage producers. It also provides insights about a country's predicted renewable production.

Energy volume coming from RES grows dynamically, which makes the previous 4RES functionality even more important.

Visit the website:
https://4res.globema.com

- prediction process
- implementation
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