SUSTAINABLE TECHNOLOGY DEVELOPMENT THROUGH SOLAR ENERGY IN VISEGRAD COUNTRIES

MISKOLCI EGYETEM
UNIVERSITY OF MISKOLC

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Visegrad V4 Countries

Reducing carbon emissions and dependence on conventional energy sources is a major challenge for all European nations, especially V4 countries. Settled in the middle of the EU, the V4 countries can significantly contribute to curbing energy security problems through cooperation. The V4 countries still have a long path to cover to reduce their dependence on fossil fuels, and renewable energy could be a possible solution.

RES status in V4 Countries

In our study, each country, namely Poland, the Czech Republic, Slovakia, and Hungary, is discussed regarding their current energy status in renewable sources. The EU aims to increase the share of renewable energy consumption; the target value is 32%. The national Energy and climate plans (NECP) reflect the renewable energy percentage share for V4 countries as Poland (23%), Hungary (21%), Czech Republic (22%), and Slovakia (19.2%) respectively by 2030. Thus, according to the current scenario, V4 nations should look for new potentials and analyze their renewable energy production strategy. Figure 1. shows a comprehensive recent status picture of the share of renewable sources in energy consumption of the V4 Countries.

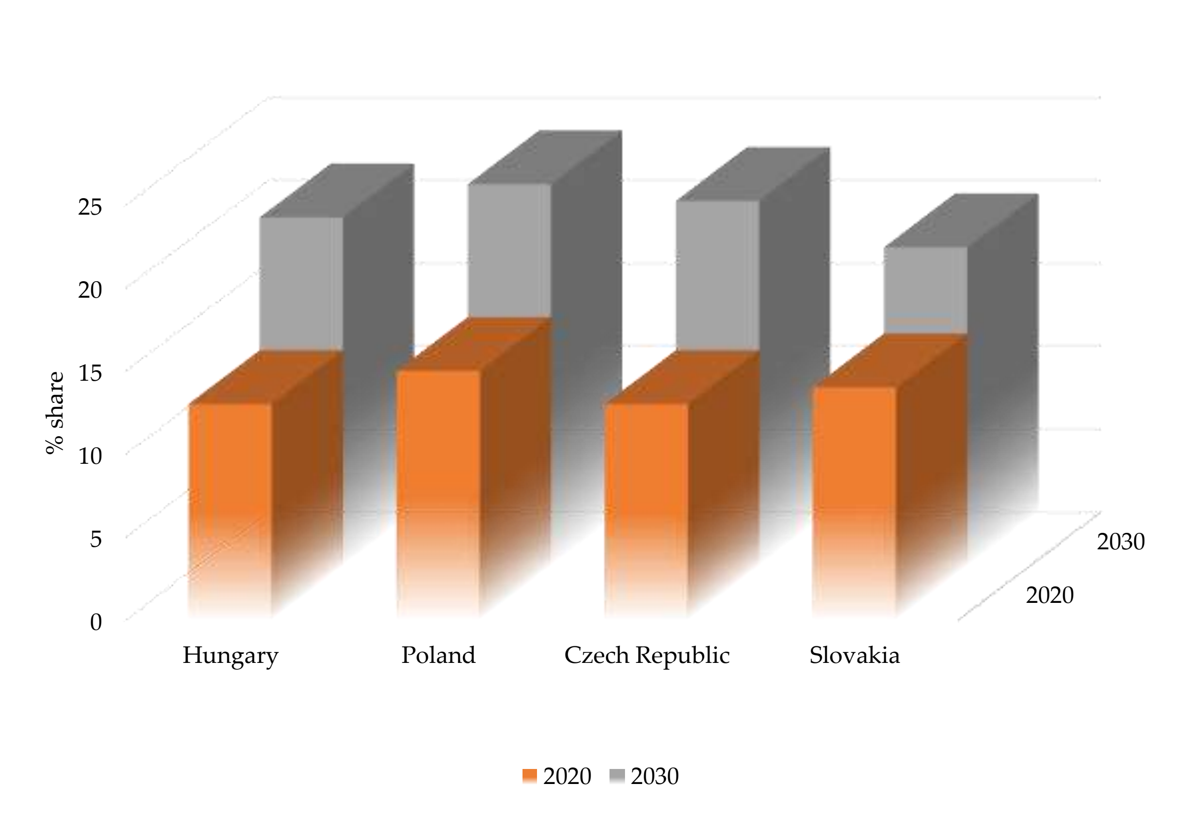
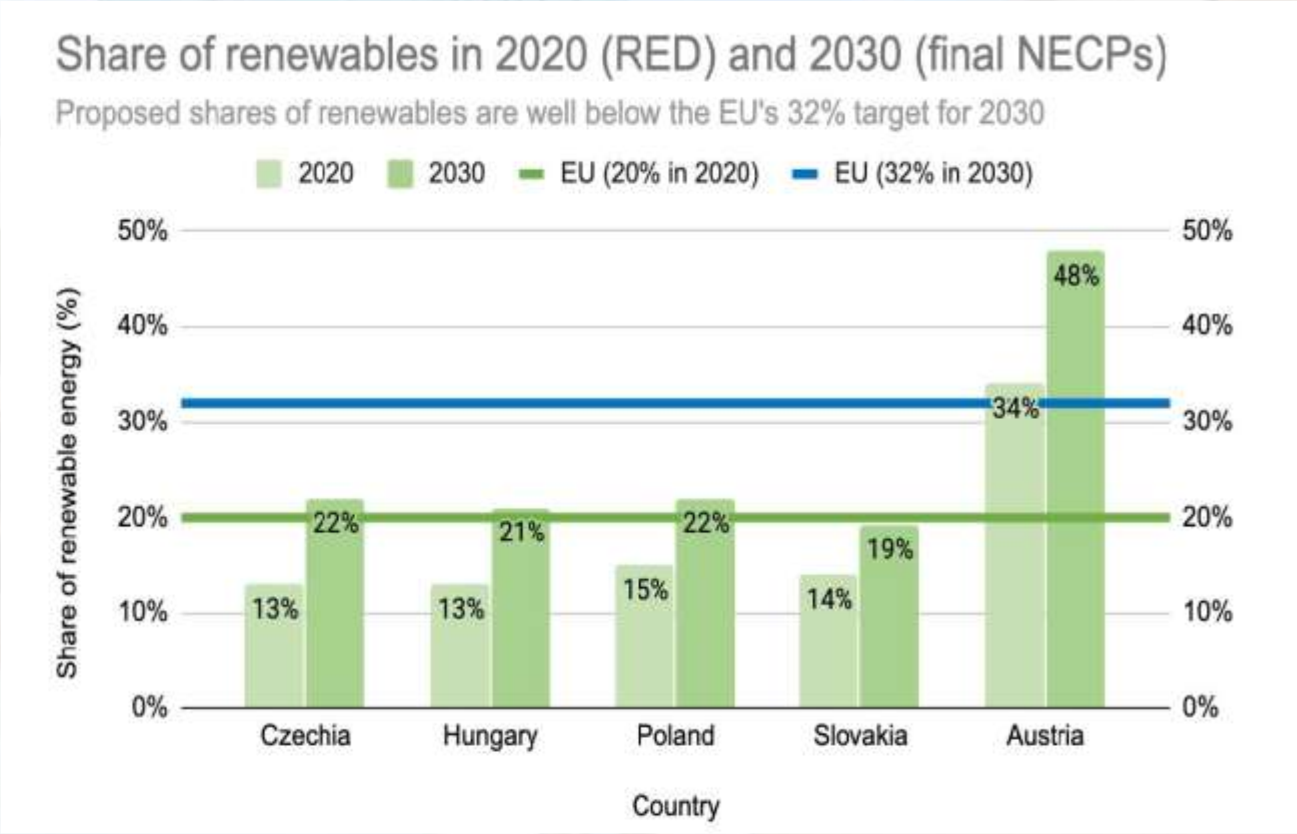


Figure 1. Share of energy from renewable sources in final gross consumption of energy in V4 Countries NECP and future expectations by 2030

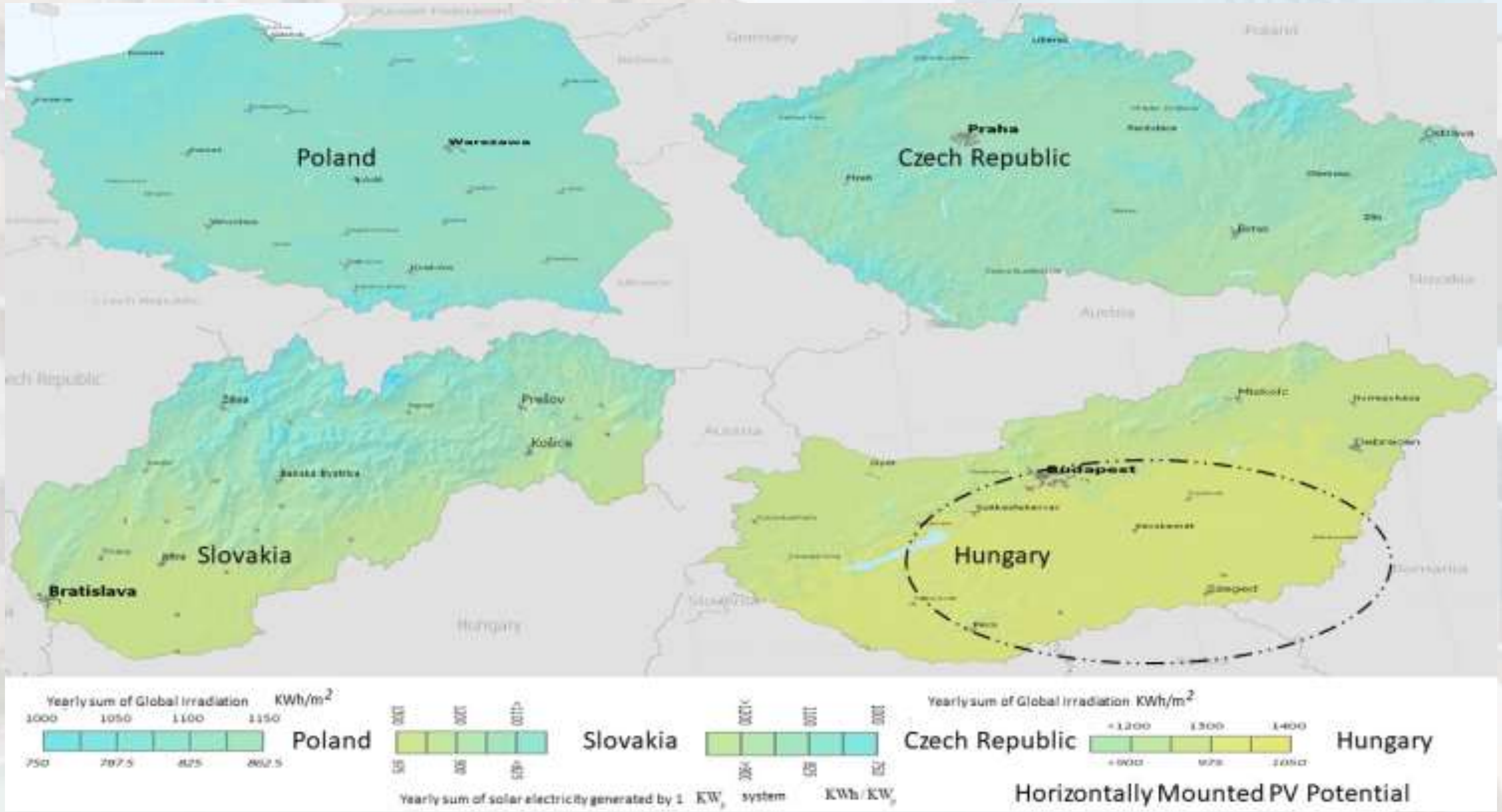
Future of RES in V4 Countries

- While the Visegrad countries lack the ambition to bet on renewables, they are no longer united in their opposition to renewable energy and ambitious climate policies.
- Governments' perspectives on renewable energy are shifting. Even in the absence of more aggressive government policies, many renewable technologies are generating a lot of interest among businesses and households.
- Facing low goals, the updated Renewable Energy Directive will be implemented in recent times as an incentive to help Visegrad countries' energy transition for the good of the environment, economies, and people.
- There will be new public funding systems, and policy will catch up to help self-consumers and clean energy societies rather than hinder them.



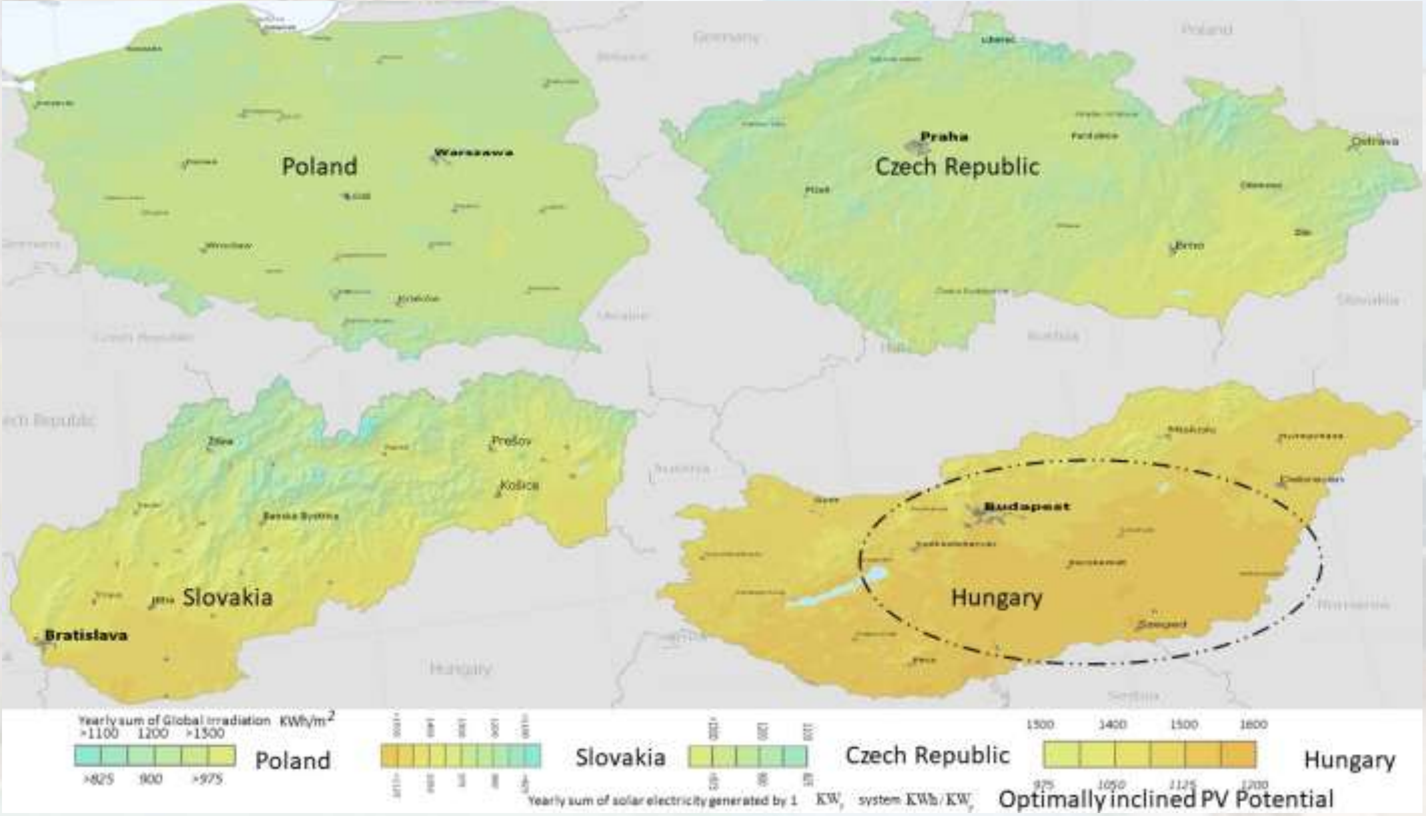
Based on Report -Visegrad+ for Renewable Energy

Can Solar Energy be a potential solution?



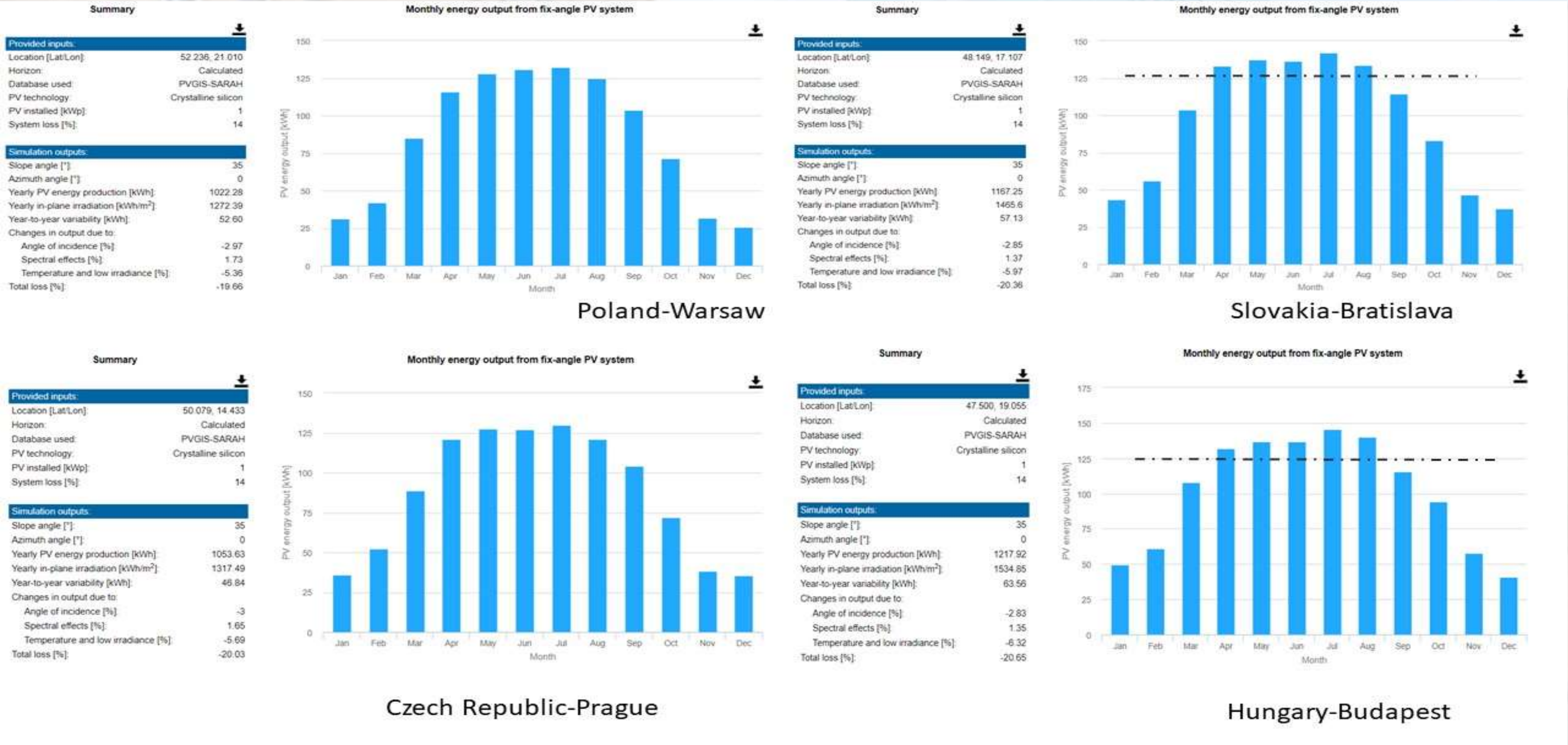
Horizontally Mounted PV Potential in the Visegrad Countries based on global irradiation and electricity generation data

Can Solar Energy be a potential solution?



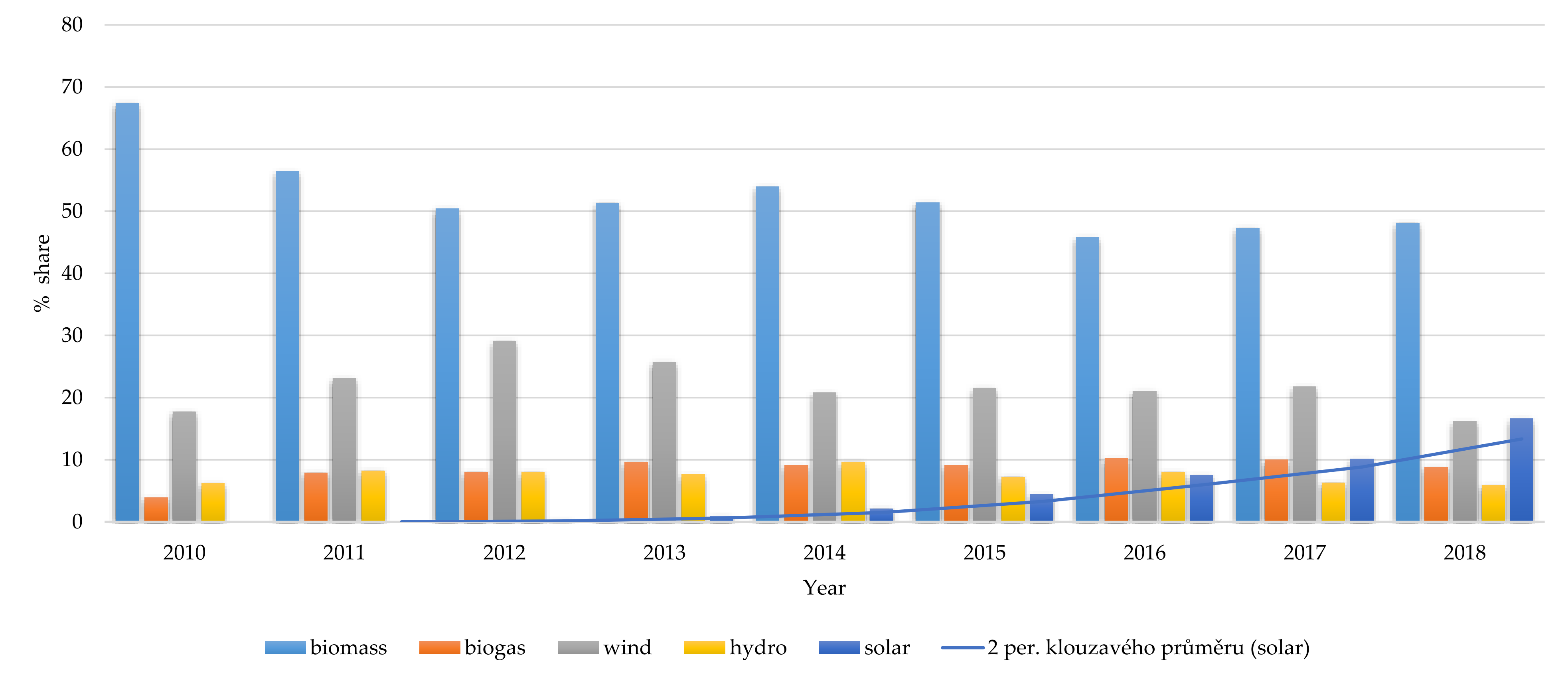
Optimally inclined PV Potential in the Visegrad Countries based on global irradiation and electricity generation data

PV Potential Assessment



Performance of Grid connected PV with energy output from fix angle PV system in the capital cities of Visegrad Countries based on European Commission PV GIS analysis tool updated in 2019

Solar Potential –Hungary Case Study



Growth Trendline of solar energy share in Hungary (2010-2018) [based on the data of the Hungarian Central Statistical Office]

Solar Parks –Hungary Case Study

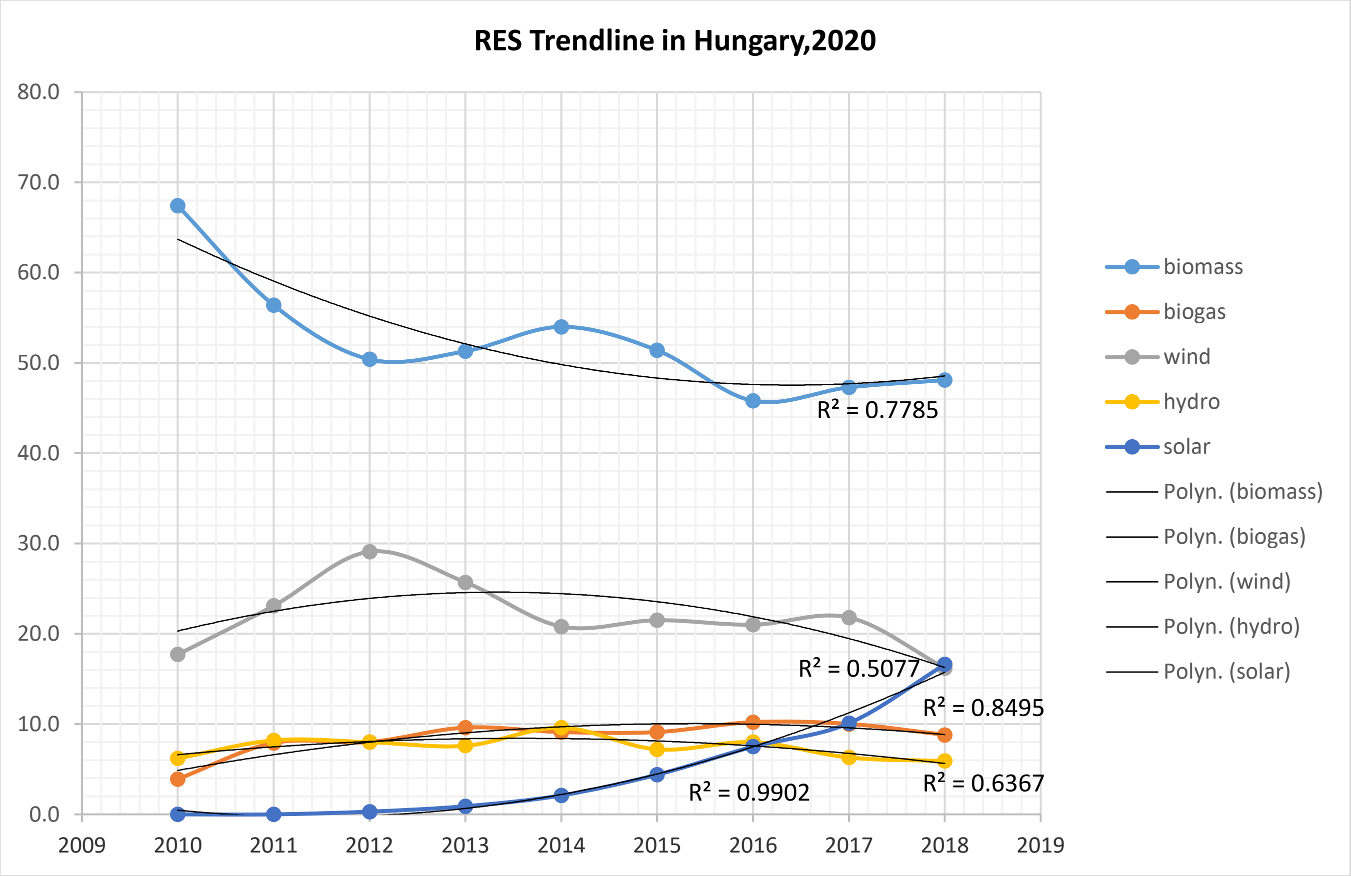
Rank	Solar Park	Capacity (MW)	Location	Established in year
1	Kaba Solar Park (UC)	43	Kaba	2020
2	Kapuvár Solar Park	25	Kapuvár	2020
3	Paks Solar Park	20.6	Paks	2019
4	Mátra Solar Power Plant	20	Bükkábrány	2019
5	Felsőzsolca Solar Park	20	Felsőzsolca	2018
6	Duna Solar Park	17.6	Százhalombatta	2018
7	Szügy Solar Park	16.5	Szügy	2019
8	Mátra Solar Power Plant	16	Visonta	2015
9	Tiszaszőlős Solar Park	11.6	Tiszaszőlős	2019
10	Pécs Solar Park	10	Pécs	2016

List of Solar parks with capacity >10MWp in various parts of Hungary

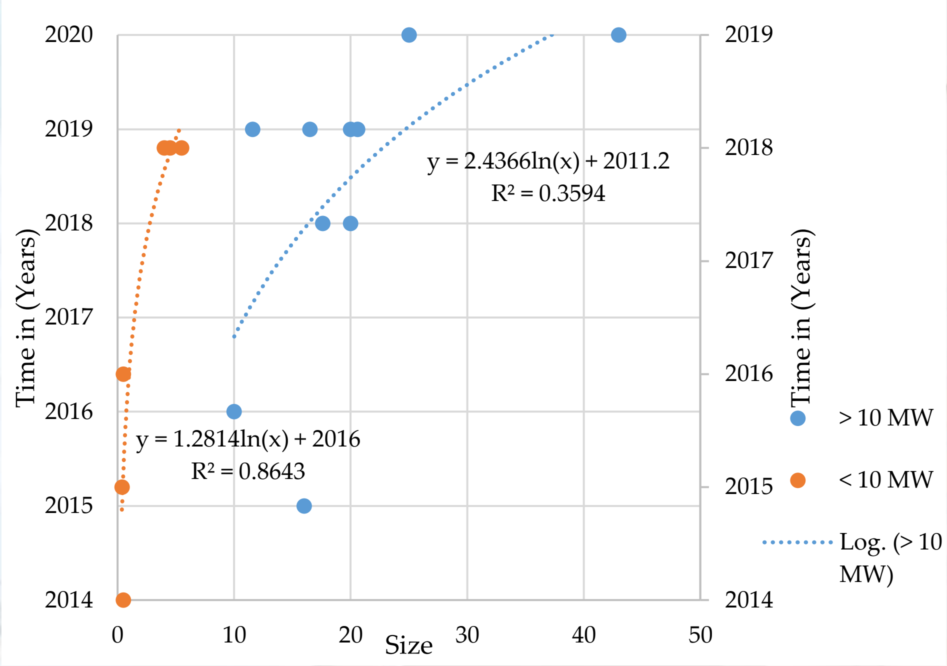
Rank	Location	Capacity M.W.	Established in year
1	Csepreg	5.5	2018
2	Vep	4.5	2018
3	Monor	4	2018
4	Sajóbábony	0.5	2016
5	Szombathely	0.385	2015
6	Bojt	0.49	2014

List of Solar parks with capacity <10MWp in various parts of Hungary

Solar Parks –Hungary Case Study



Critical Regression line analysis of Solar parks future growth trends in Hungary (2010-2020)



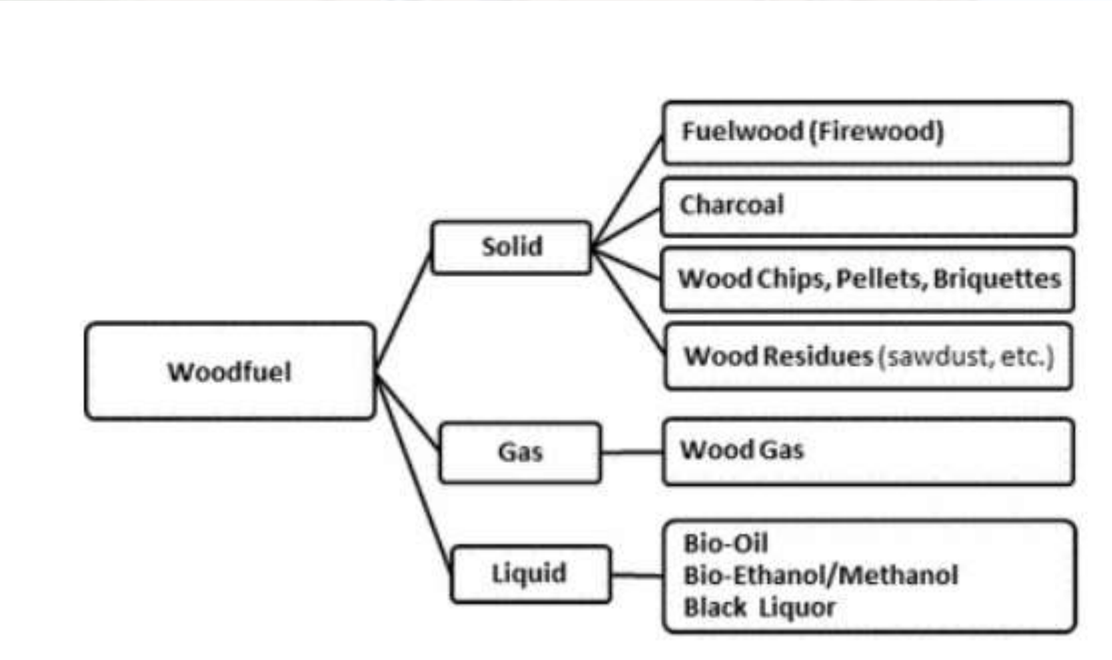
Critical Regression line analysis of Solar parks future growth trends in Hungary (2010-2020)

Optimal utilization solution map

Solar parks presence in various regions of Hungary based on power capacity

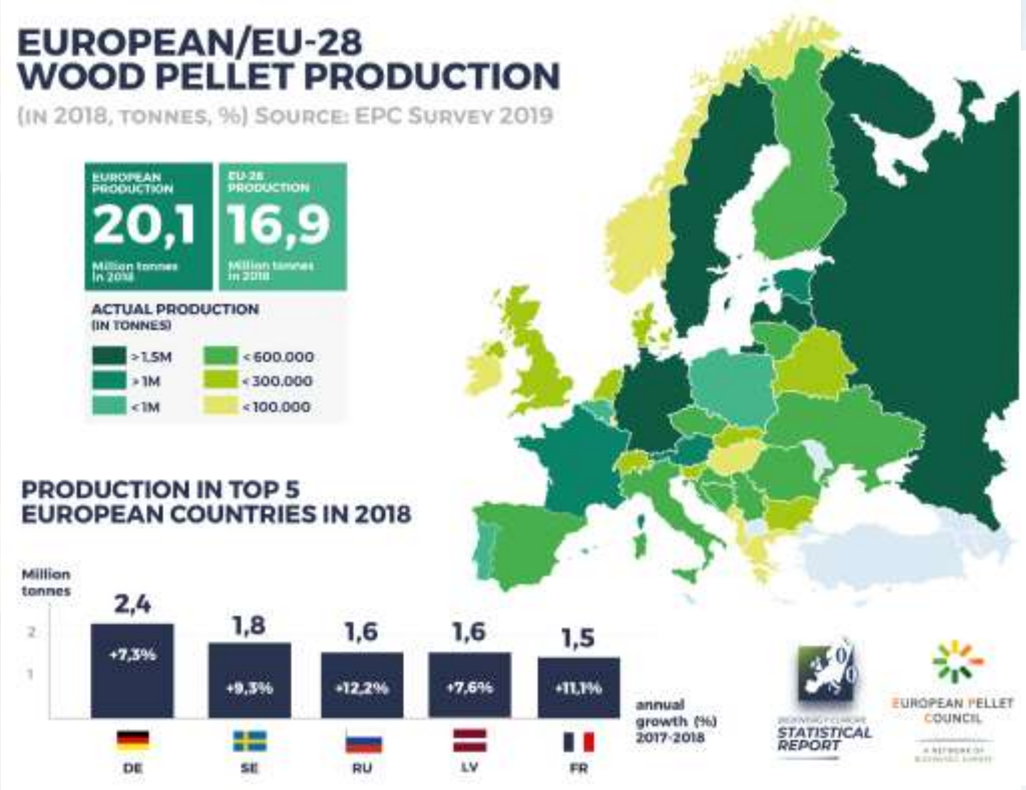
The results are promising about solar power production in the coming future. In the Regional map study, exciting insights were revealed in the map analysis, which was done to understand the distribution of power plants set up around the nation. It could be observed that there is a cluster of solar parks with more enormous capacities in the Northeastern region. Very few power plants could be seen in the lower southern parts of the country. The study recommends utilization of the untapped potential of the southern and eastern parts of the country.

Sustainability Problems of EU?



Categories of wood fuels and SDG roles

"Wood energy is the energy generated from wood or wood-derived products as energy source– usually through combustion processes – and are used primarily for cooking, heating or electricity generation.
And contributes to SDG Goals 2,7,12 and15"



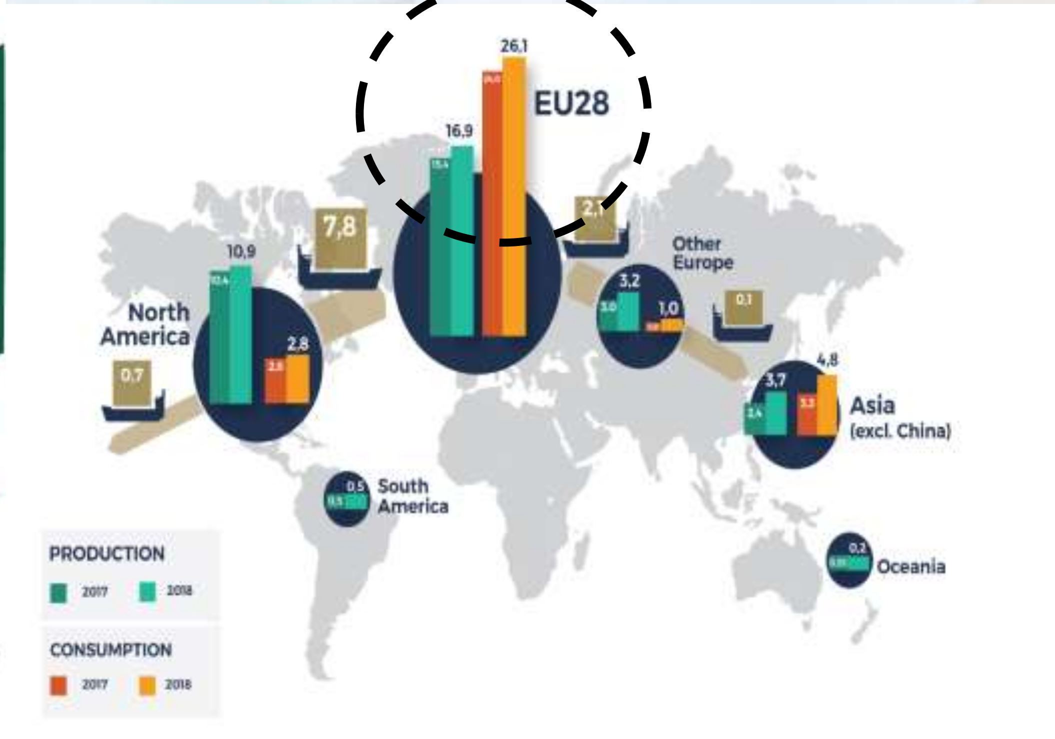


Figure 2. Production in wood fuels in EU and worldwide (consumption and demand) [1]

- Global wood pellet consumption reached 35 million tonnes.
- Europe is the largest pellet consumer in the world with 27 million tonnes of pellets being consumed annually.
- The EU28 saw a significant growth of around 2 million tonnes .
- With a production volume of 20,1 million tonnes 2018 to 23.1 in 2021. Europe solely supplies 74% of its pellet use.

What
is the MAJOR challenge associated with Wood Fuels?

- Combustion of wood with different moisture content was studied in a domestic stove for calorific value.
- Moisture content influences the burning rate and the emissions.
- High moisture content fuels will result in increased particulate emissions.
- High moisture content leads to higher levels of brown carbon emission. [2]

How
Does it affect the efficiency of Wood Fuels?

"Wood fuel with **less** than 20% moisture content is over **two** times **more efficient** than fuel with over 45% moisture content. As the moisture decreases, the energy within the wood increases" [3]

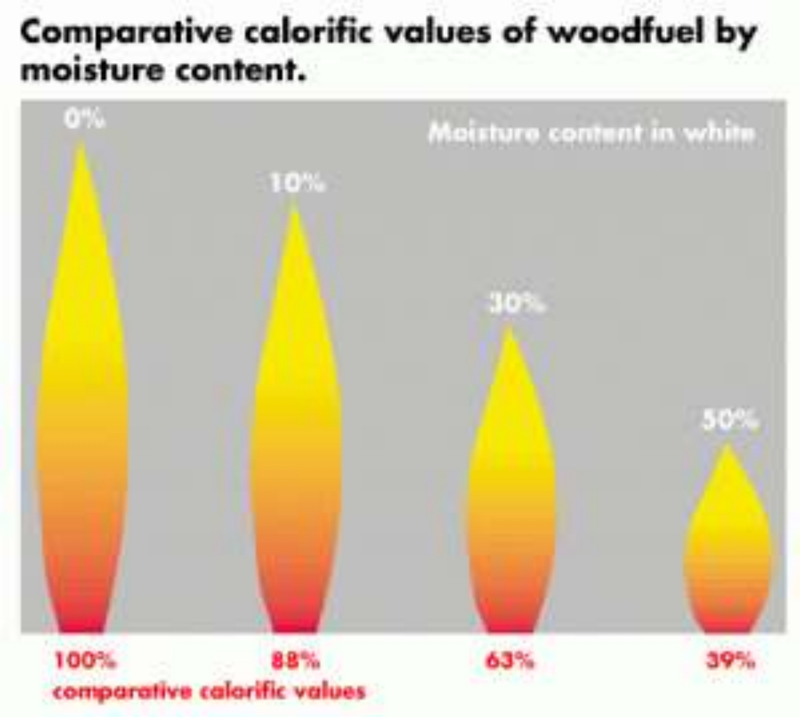


Figure 3. Role of moisture in wood fuels [4]

Can Solar energy play a role in solution?

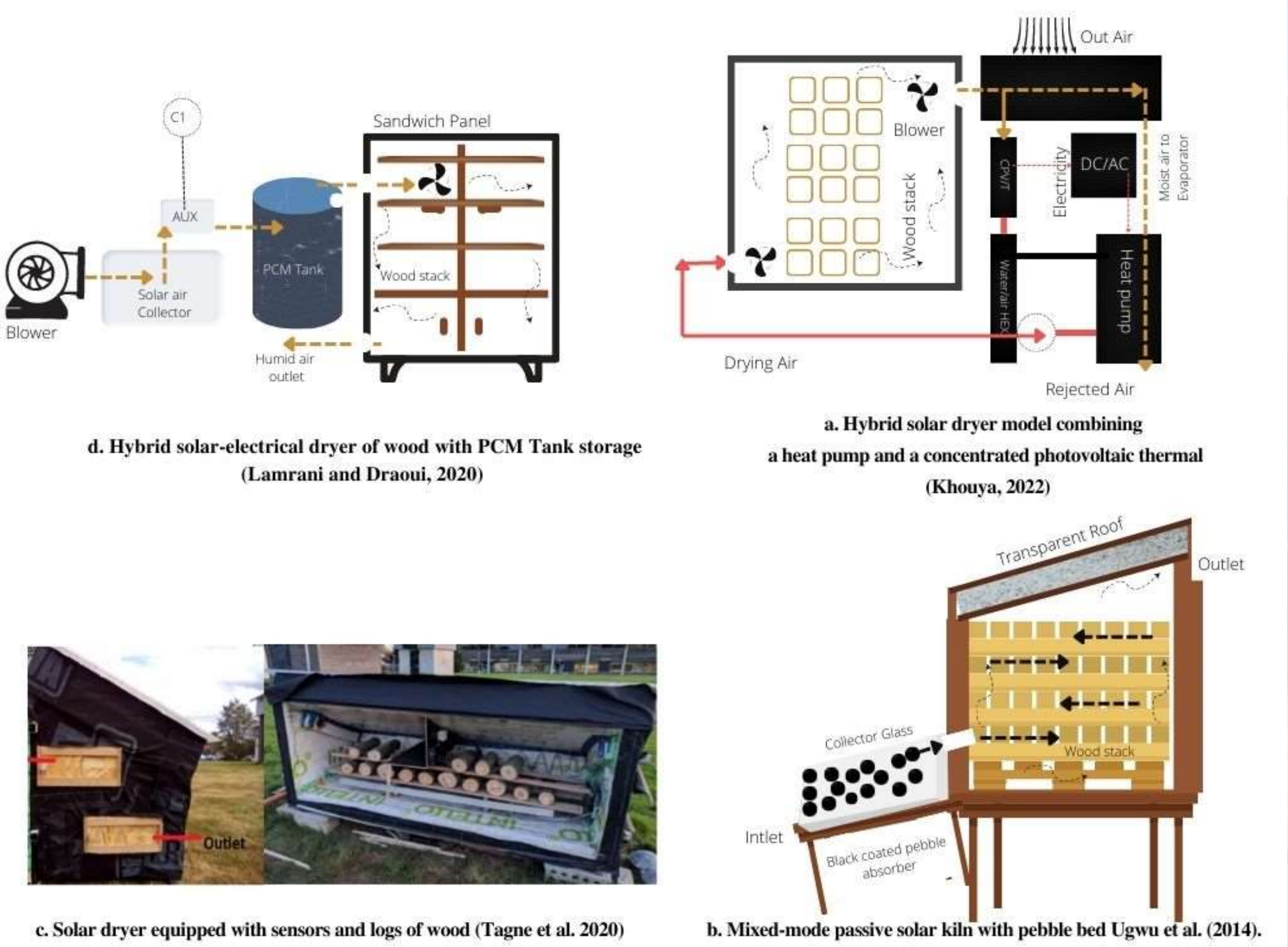


Figure 4. Various dryer designs attempted for solar drying of wood fuels [5], [6], [7], [8]

What

is the sustainable solution to reduce the moisture from wood fuels?

Sustainable Solar Drying

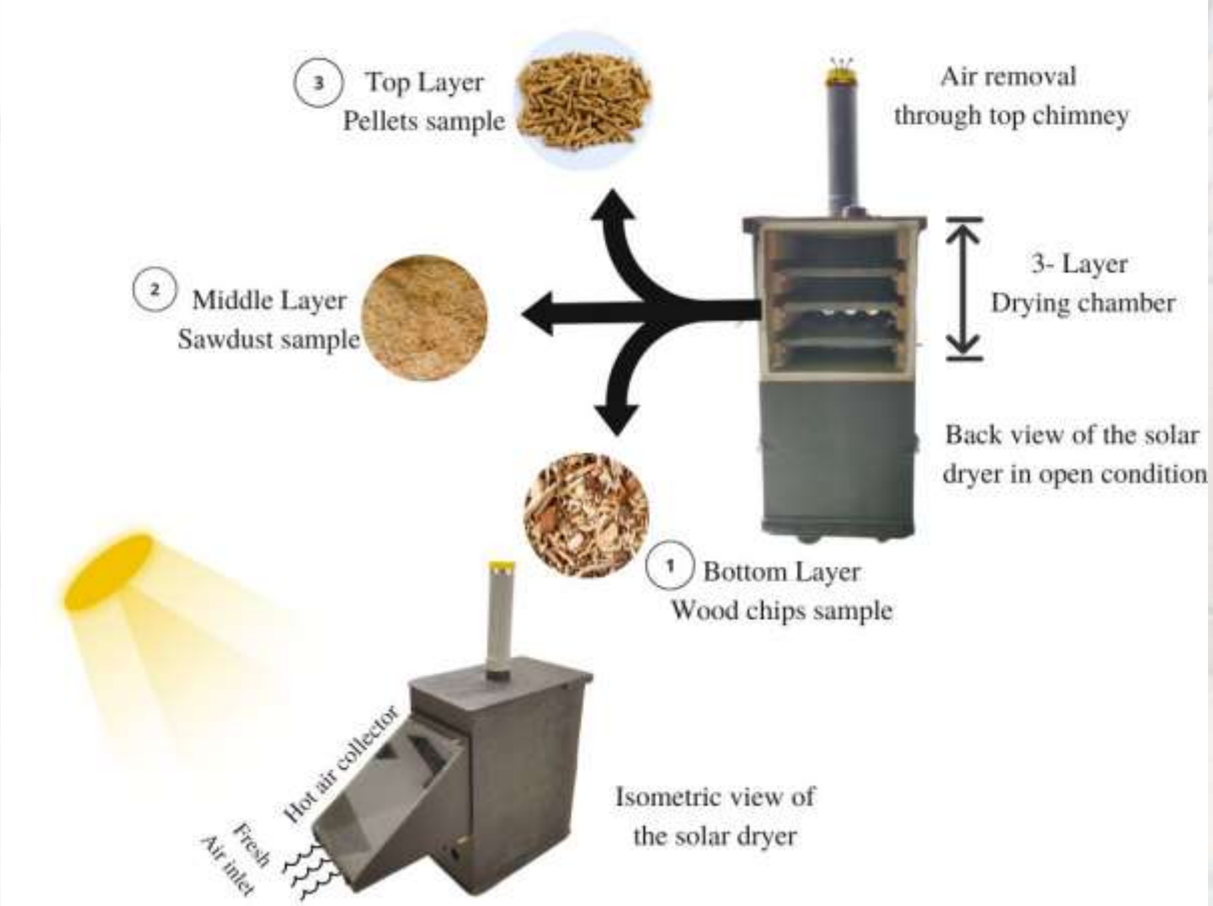
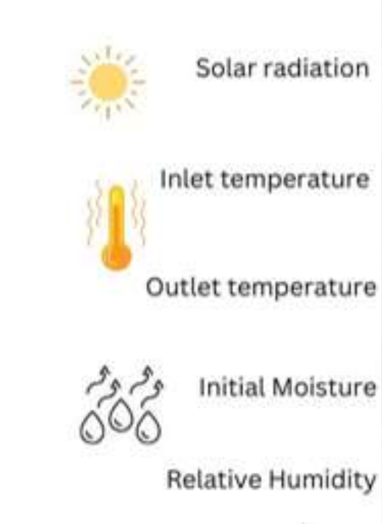


Figure 5. Lab scale-Experimental setup for measurements

But
How efficient is Solar Drying for wood fuels?

Parameters?



Methodology?

- Energy efficiency of collector

$$\eta_{th,c} = \frac{\dot{m}C_p(T_o - T_i)}{I_T A_c}$$

- Exergy efficiency

$$\eta_{th} = \frac{Ex_u}{Ex_{in}}$$

- System Efficiency

$$\eta_{system} = \frac{m_{water} \times h_{fg}}{I_T A_c + E}$$

Figure 4. Measurements with sensors

What was the Experimental results?

Solar Radiation

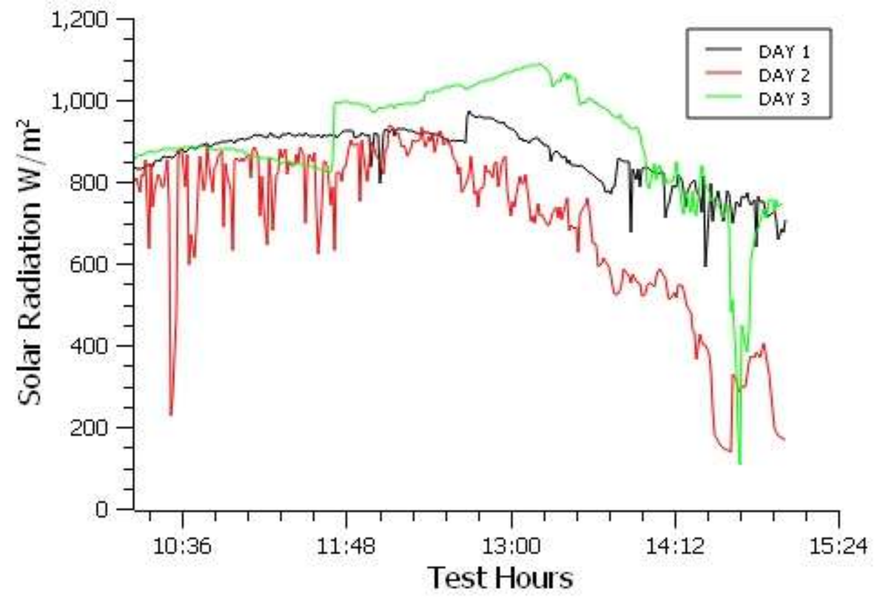


Figure 6. Solar radiation v/s test hours

Thermal Efficiency

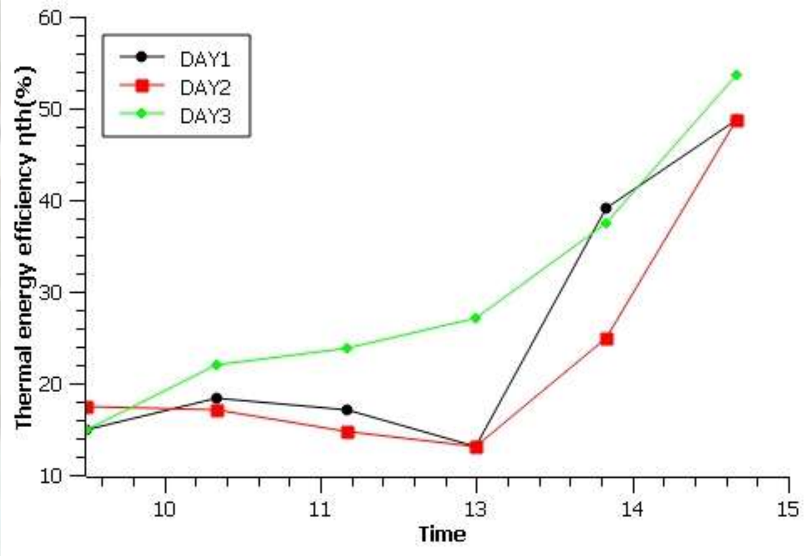


Figure 7. Thermal energy efficiency calculated v/s test hours

What was the Experimental results?

Exergy gain and Energetic efficiency

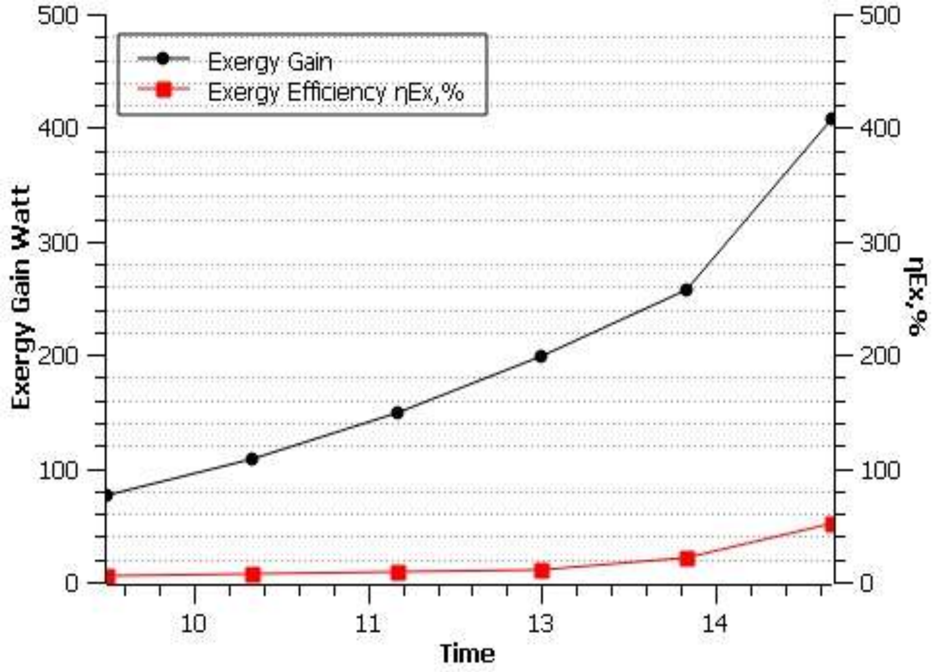


Figure 8. Exergy gain efficiency calculated and v/s test hours

Moisture ratio

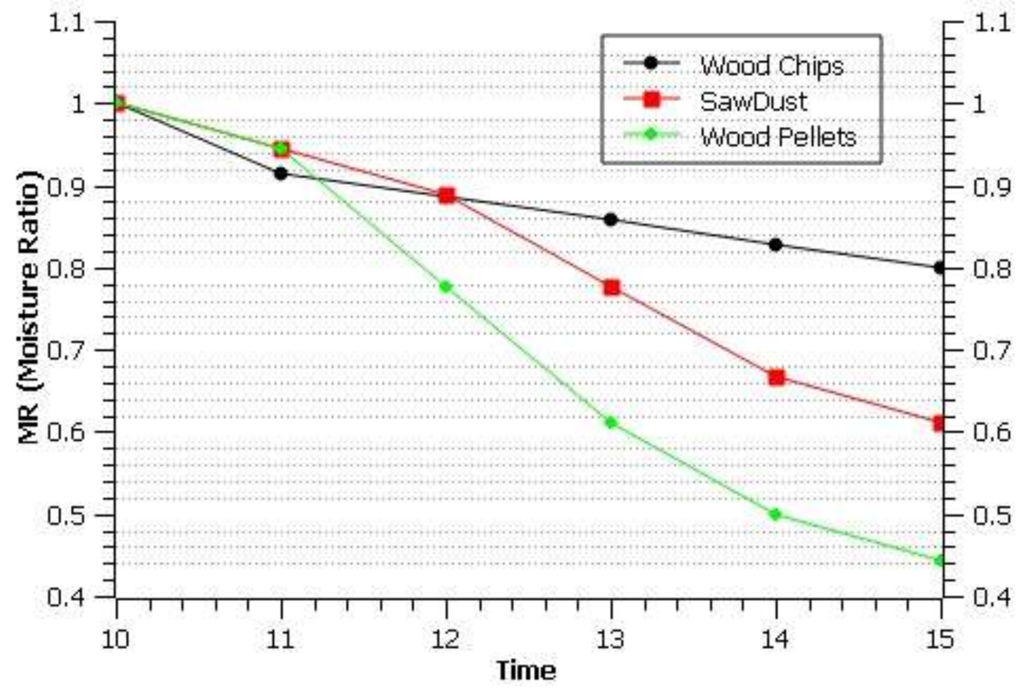


Figure 9. Moisture ratio v/s test hours

Is there any process to predict or validate the results?

YES
There are several tools used for predicting the moisture removal from agricultural products with Solar drying.
Some commonly used are optimization techniques are ANN(Artificial Neural Network),Finite element Analysis(FEA), Genetic Algorithms (GA),Computational fluid dynamics(CFD) etc.

Novel ANN model to predict the Final Moisture content with MATLAB

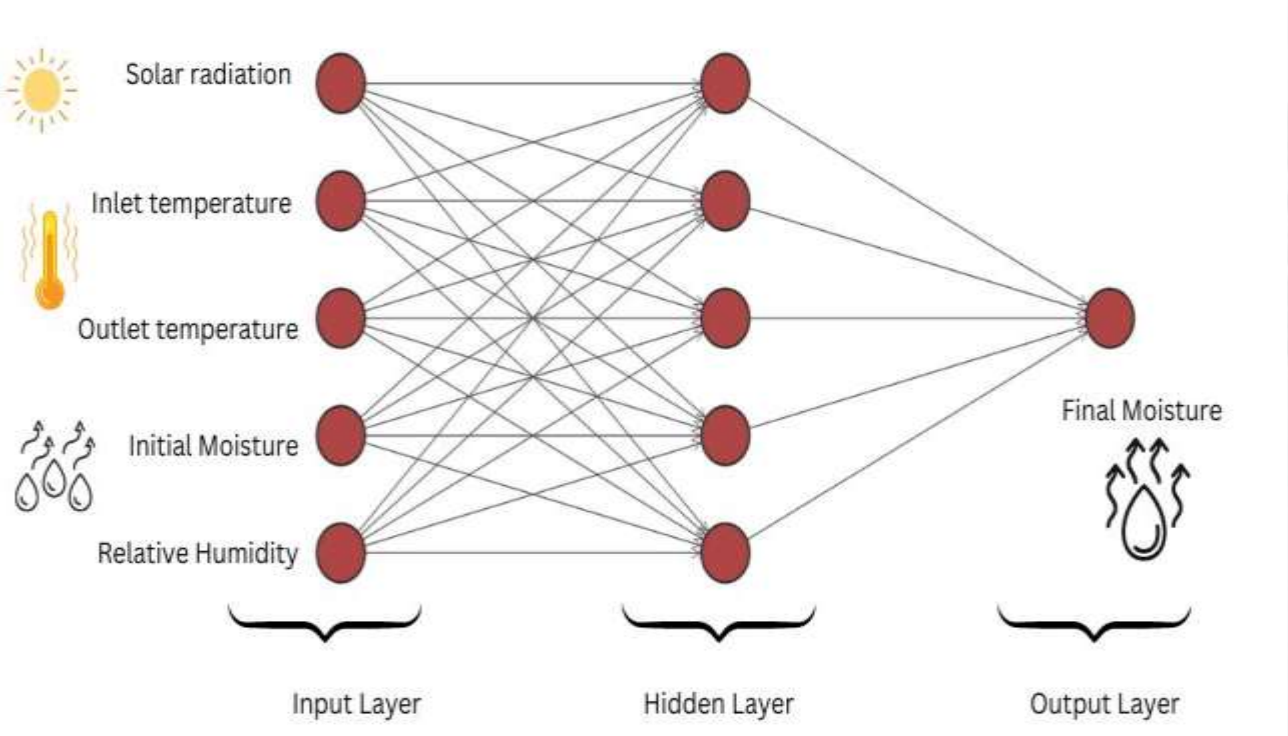


Figure 10. Graphical ANN model

Parameters	Range	Units
Solar Radiation	100-1100	W/m^2
Inlet Temperature	18-32	°C
Outlet Temperature	20-60	°C
Initial Moisture content (wet basis)	32-36	%
Final moisture content (wet basis)	16-28	%
Relative Humidity	25-75	%

Validation results of the simulation?

The ANN-optimized model was found suitable with reasonable values of Coefficient of correlation (R) for the model with MATLAB simulations.

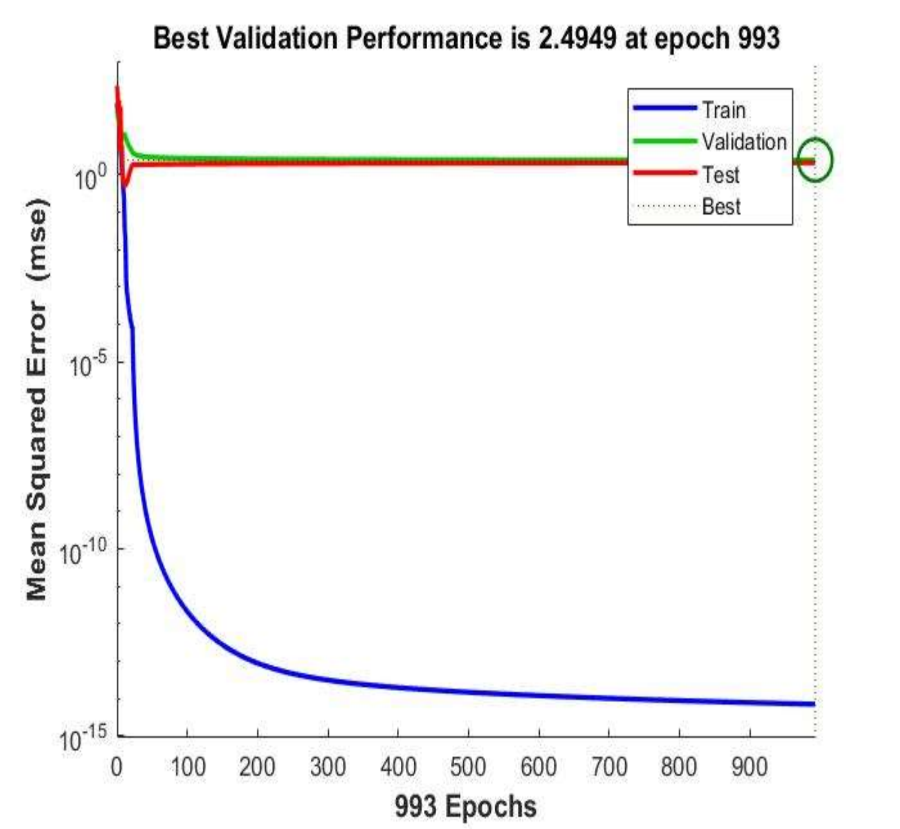


Figure 11. MSE validation in MATLAB

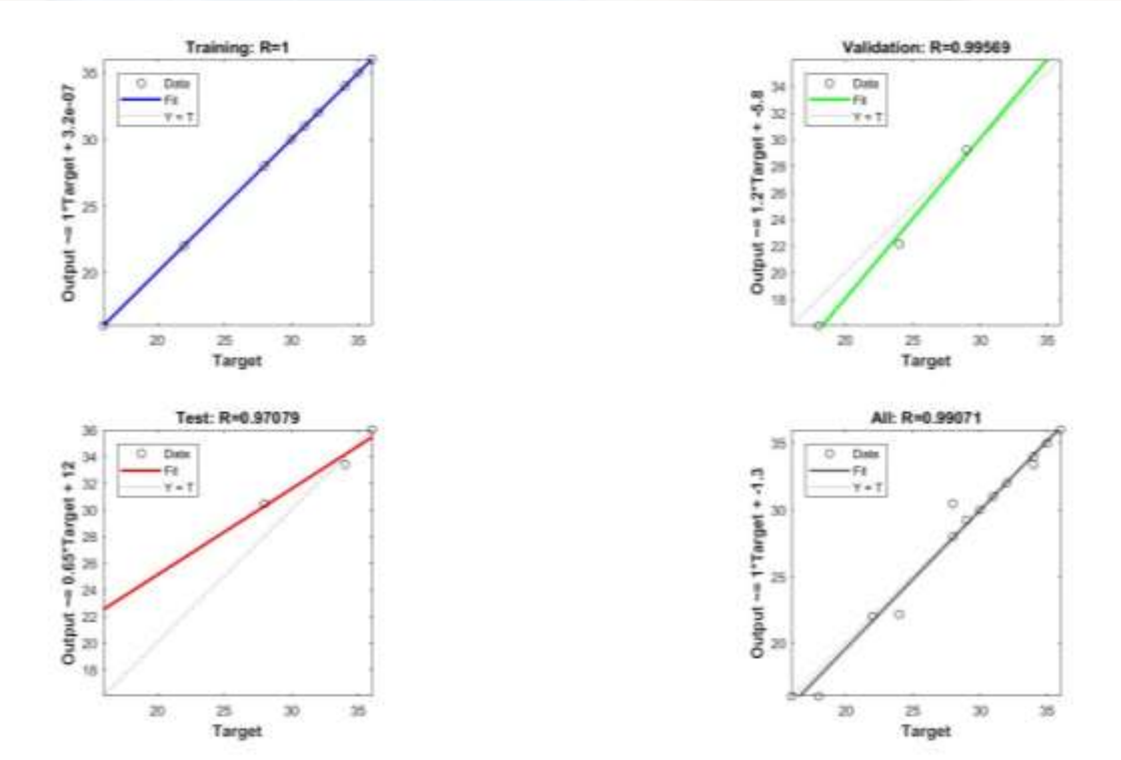


Figure 12. Fitness of R values in test and validation

Research Results

Figure 12. Pictures of samples before and after solar drying

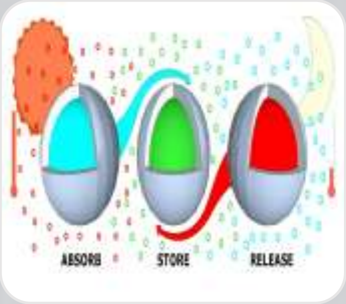
The highest temperature recorded was 60°C, with radiation of 1100W/m2. The maximum thermal energy and exergy efficiency observed during experimental hours as 55% and 51.1%, respectively.

Sawdust and pellets had better drying rates than woodchips.

The overall system efficiency of the dryer with respect to the woodchips, sawdust, and wood pellets was found to be (19.04-29.9)% ,(23.34-33.2)%, and (21.11-31.1)% for the three days of experiments.

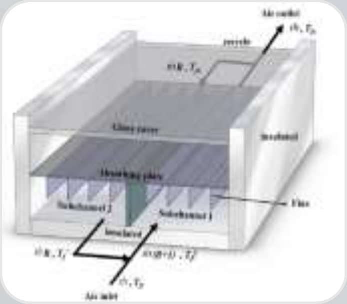
An ANN model was created to predict the final moisture content for the system. A good coefficient of correlation (R) value revealed the model's suitability

Future pathway of research



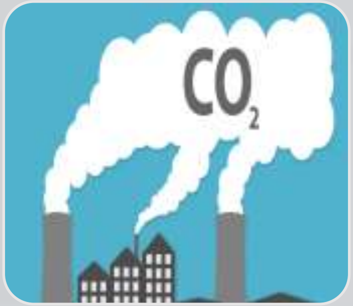
Further research required to make the drying continuous using the Phase change materials such as paraffin wax or salt, etc.

Drying observations to be investigated using the artificial sun with continuous high intensity radiation.



Design modifications could be done in collector to investigate the comparative results.

Other agricultural products can be investigated for dryer optimization.



Environmental impact and carbon reduction impact.

References

[1] Source: https://epc.bioenergyeurope.org/

[2] https://doi.org/10.1016/j.fuel.2018.11.090

[3] https://www.installeronline.co.uk/low-moiature-content-woodfuel-essential-for-efficiency/#:~:text=Woodfuel%20with%20less%20than%2020,energy%20within%20the%20wood%20increases

[4] https://backwoodsman-stoves.co.uk/calorific-value-of-woodfuel-by-moisture-content/

[5] A. Khouya, “Energy analysis of a combined solar wood drying system,” *Sol. Energy*, vol. 231, pp. 270–282, 2022, doi: https://doi.org/10.1016/j.solener.2021.11.068.

[6] S. N. Ugwu, B. O. Ugwuishiwu, O. V Ekechukwu, H. Njoku, and A. O. Ani, “Design, construction, and evaluation of a mixed mode solar kiln with black-painted pebble bed for timber seasoning in a tropical setting,” *Renew. Sustain. Energy Rev.*, vol. 41, pp. 1404–1412, 2015, doi: https://doi.org/10.1016/j.rser.2014.09.033.

[7] M. Simo-Tagne, M. C. Ndukwu, and M. N. Azese, “Experimental Modelling of a Solar Dryer for Wood Fuel in Epinal (France),” *Modelling* , vol. 1, no. 1. pp. 39–52, 2020, doi: 10.3390/modelling1010003.

[8] B. Lamrani and A. Draoui, “Modelling and simulation of a hybrid solar-electrical dryer of wood integrated with latent heat thermal energy storage system,” *Therm. Sci. Eng. Prog.*, vol. 18, p. 100545, 2020, doi: https://doi.org/10.1016/j.tsep.2020.100545.

Thanks for Listening!

Köszönöm!

Ďakujeme :)

NAMASTE