6th International Conference on Smart Energy Systems
6-7 October 2020
#SESAAU2020

Evaluation of energy efficiency measures in district heating systems with deep learning

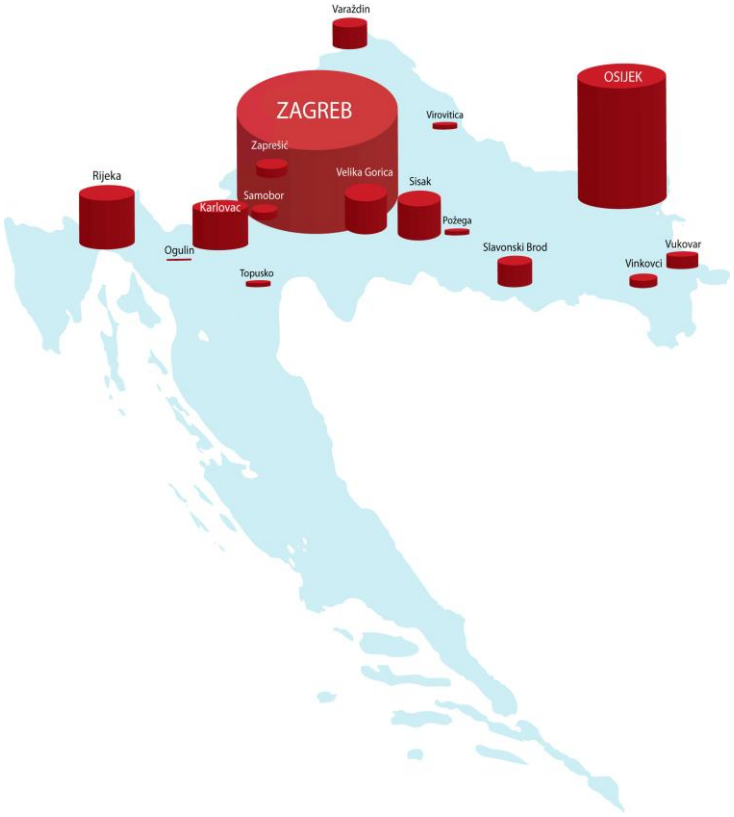
Danica Maljkovic, *Dok-Ing Energo, Croatia*
Prof Tomasz Cholewa, *University of Lublin, Poland*
Prof Bojana Dalbelo Basic, *University of Zagreb, Croatia*
Prof Igor Balen, *University of Zagreb, Croatia*

Powered by

Heat consumption in district heating

- Physical characteristics of a building
- Influential parameters on consumption
- Behavioural parameters

It has been noticed that there is a significant difference between design and actual consumption within a building – due to behavioural parameters.



How to foresee heat consumption in district heating?

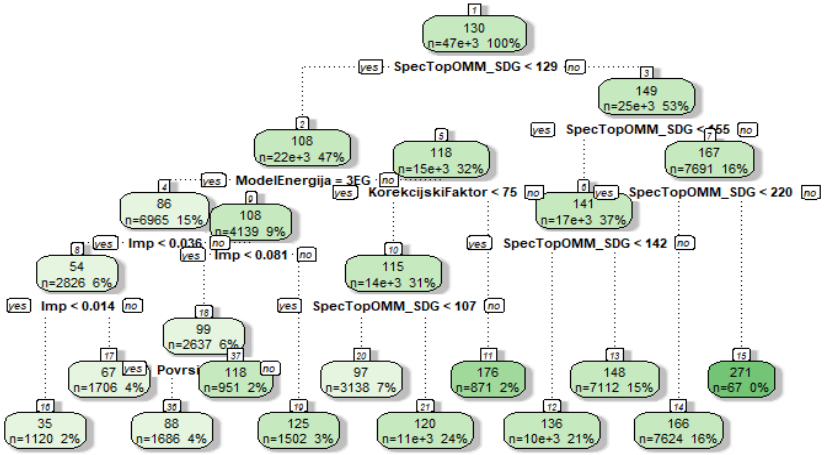
Machine learning:

1. MLR
2. Regression Trees
3. Random Forest
4. SVM

Furthermore – deep learning?

Case – Croatia. Test on Poland. New deep learning case on Croatia and Poland.

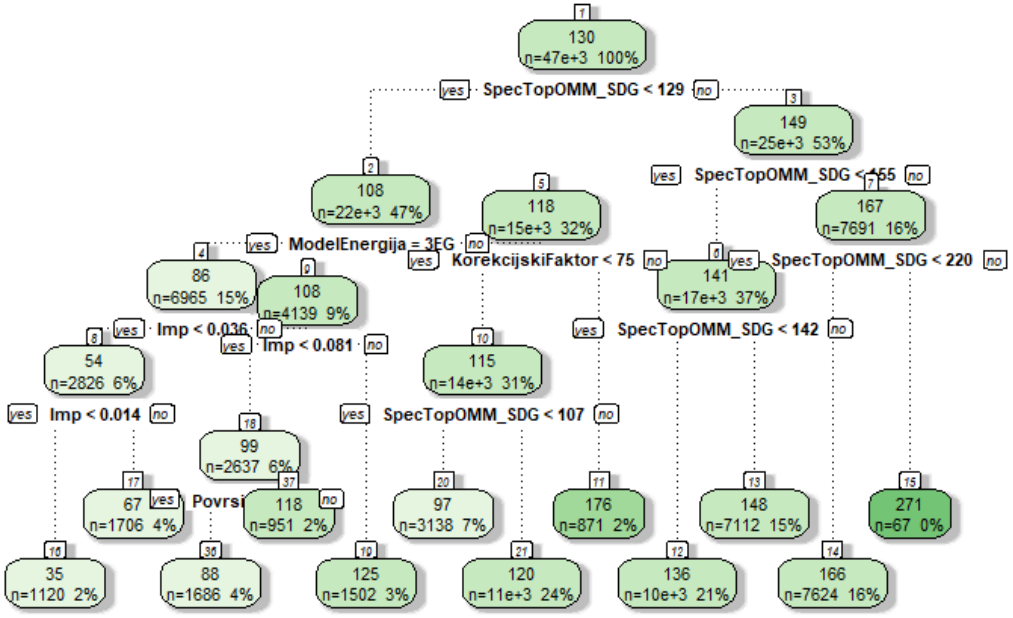
- MLR:
  - $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \epsilon$
- Regression Trees
- Random Forest
- SVM



Powered by

Apartment Level

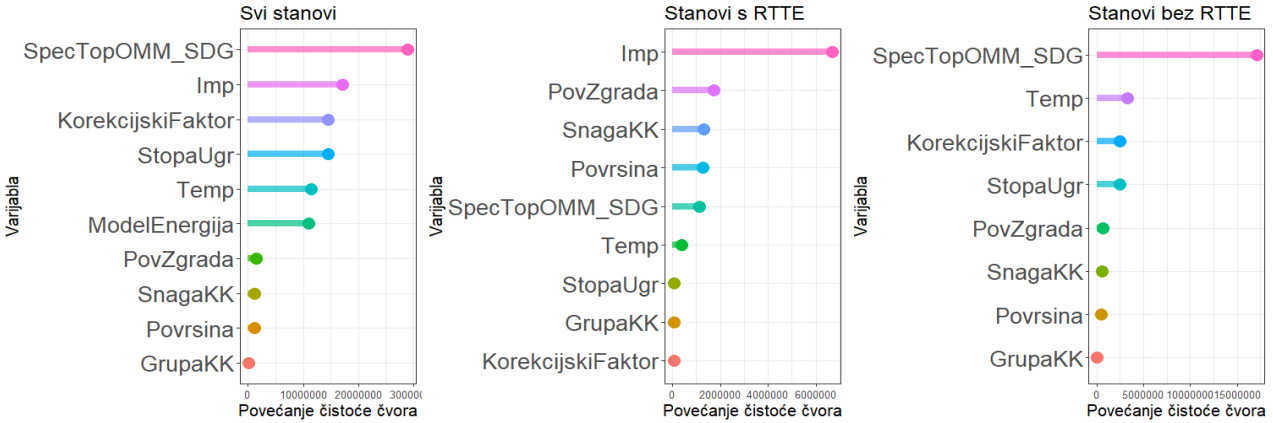
$$SpecTopSDG = 29{,}03 - 123{,}13 \cdot ModelEnergija3EG + 639{,}67 \cdot Imp +$$
$$+0{,}96 \cdot SpecTopOMM_{SDG} + 80{,}14 \cdot StopaUgr - 3{,}42 \cdot Temp -$$
$$-0{,}258 \cdot Povrsina + 0{,}002 \cdot PovZgrada$$



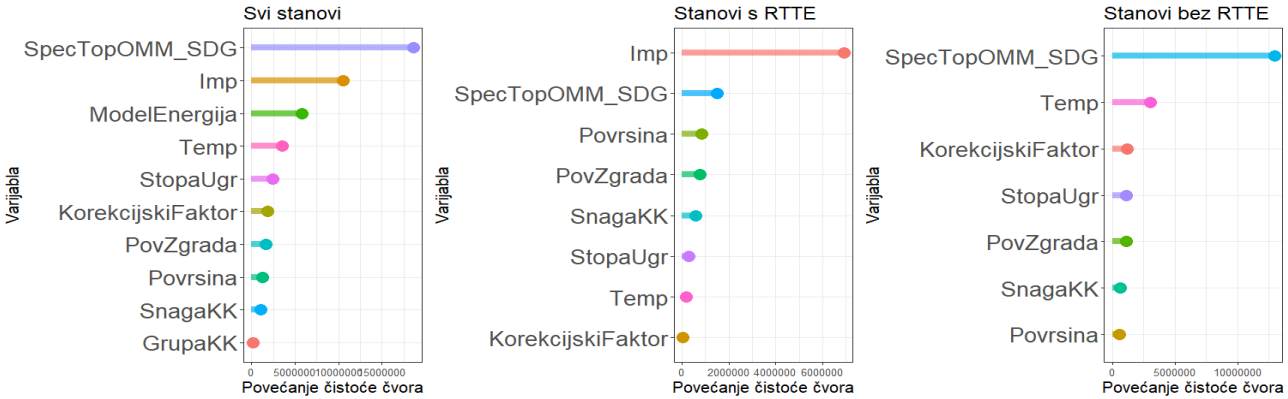
DOK-ING

6th International Conference on Smart Energy Systems
6-7 October 2020
#SESAAU2020

– Regression Trees



– Random forest



Powered by

AALBORG UNIVERSITY DENMARK

sEEnergies

Innovation Fund Denmark

reINVEST

midt regionmidtjylland

DEN EUROPÆISKE UNION
Den Europæiske Fond for Regionaludvikling
Vi investerer i din fremtid

GRØN ENERGI

kamstrup

LOGSTOR

Ørsted

Aalborg Forsyning

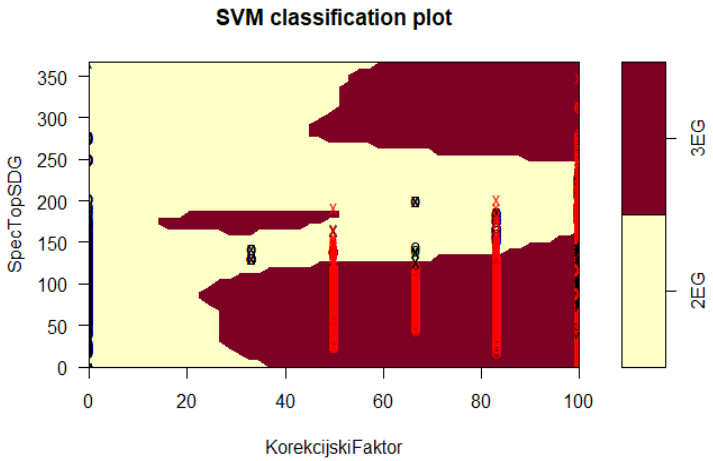
Evaluation of each machine learning algorithms considered for this application.

a compromise between accuracy and interpretability

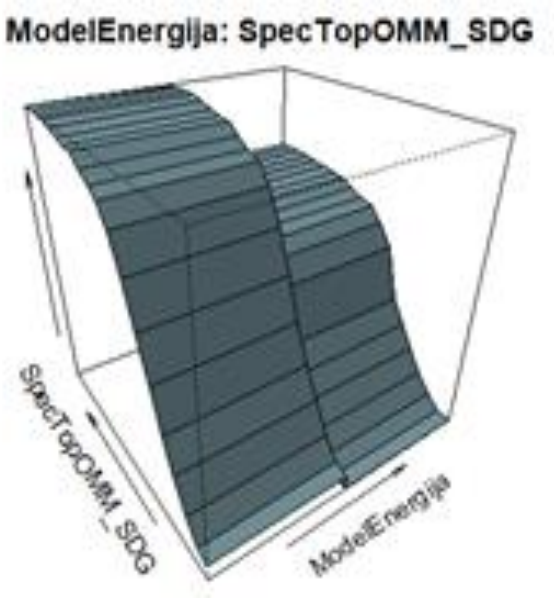
- Random forests (apartments +/- 4.27 kWh / m2, buildings 13.24 kWh / m2)
- Multiple linear regression (apartments +/- 16.44 kWh / m2, buildings 16.59 kWh / m2)
- For interpretability with the highest possible accuracy - regression trees
- For accuracy - random forests

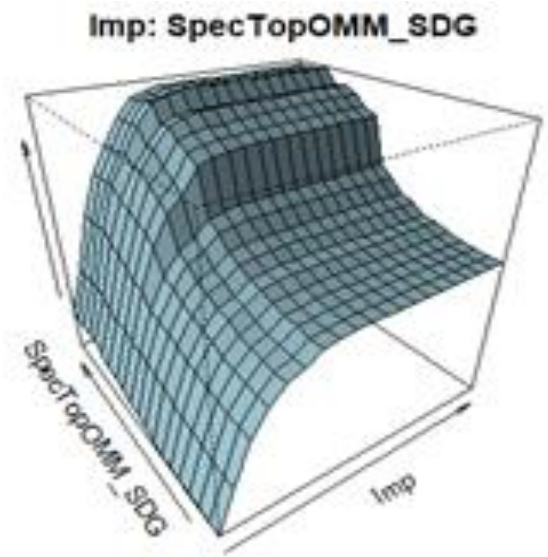
	RMSE
MLR	16,44 kWh/m^2
Regression Trees	11,78 kWh/m^2
Random Forest	4,27 kWh/m^2
SVM	5,96 kWh/m^2

- Comparison with ML algorithms for Polish data
  - data for 107 buildings for years 1997 - 2014
- Expected to get similar forecasting accuracy, different regression functions
- Further analysis with deep learning
  - Neural Networks
  - Convolutional Neural Networks
  - Recurrent Neutral Network

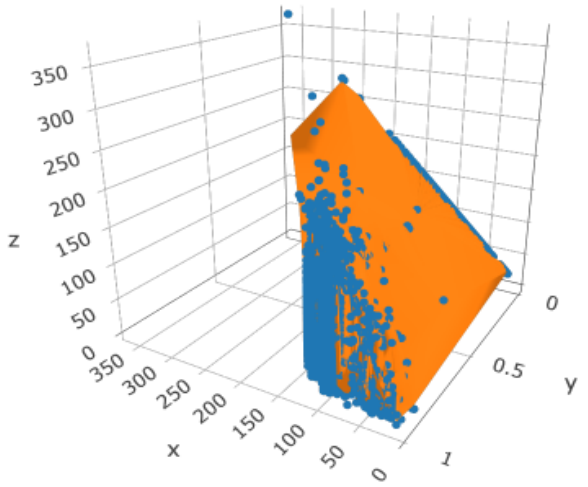


- Total of 5M observations for 2 towns in Croatia and 1 town in Poland (seeking and welcoming new towns – danica.maljkovic@dok-ing.hr)
- High precision model, low on interpretability!





- Plan to reach other district heating systems, first Europe, possibly global
- All of the analysis should be based on the easily accessible date – billing / invoices
- Possibility for the final consumers to use the model and monitor and compare their consumption (while providing data in accordance with GDPR)



THANK YOU FOR ATTENTION!

danica.maljkovic@dok-ing.hr

Powered by