A Critical Comparison Of Methods For Benchmarking Energy Performance In WWTPs

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inspiring change

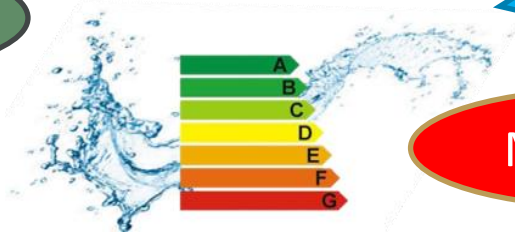
WHY ENERGY BENCHMARKING?

Monitor the effect of new actions

DEFINE

Define energy consumption indicators

CONTROL



MEASURE

Take representative samples

IMPROVE

ANALYSE

Compare with other plants. Link the measurements with the plant operation

Implement actions to improve the energy efficiency

H2020 Coordination and support action ENERWATER. www.enerwater.eu

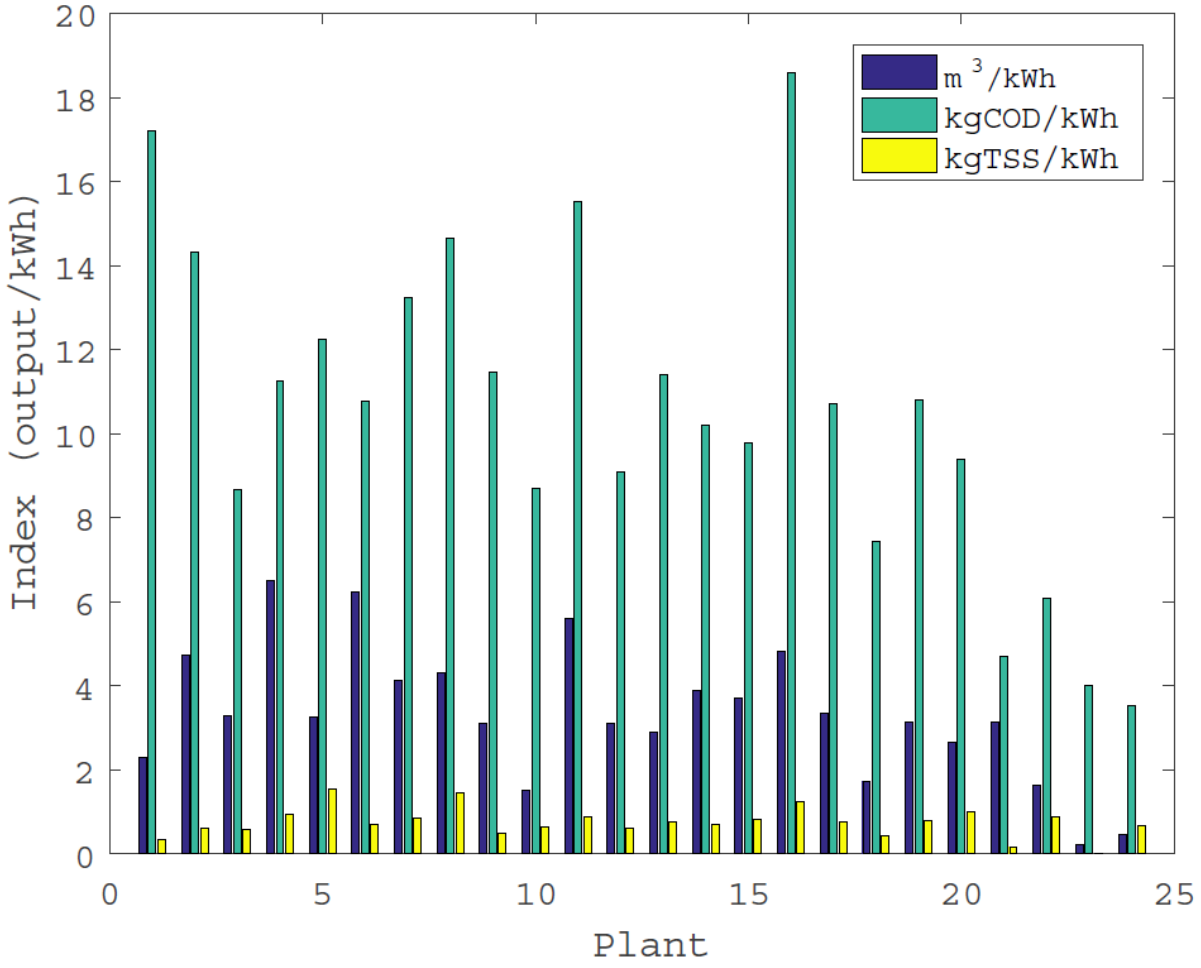
COMPARISON OF METHODS

Index methods	Data Envelopment Analysis	Regression methods
Pros - Easy to implement and understand - Statistical tests are readily available	**Pros** -Ready for multiple inputs/outputs -No need to specify a functional form -Useful for a given set (e.g. the WWTPs of an operator) - Can account for scale effects	**Pros** - Statistical tests are readily available - Composite result (the performance can be compensated) - Exogenous variability readily included - Provides effect and size of inputs and exogenous variables→diagnosis
Cons -No scale effects - Exogenous variability cannot be accounted for - Need of composite index for multiple inputs/outputs	**Cons** -Can provide too many optima if many inputs/outputs - Sensitive to measurement error and outliers - Statistical tests are cumbersome - Finite sample effect - Exogenous variability is difficult to include - Homogeneous set of input/output	**Cons** -Composite result (the performance can be compensated) - Scale effects require the right functional form - Sensitive to outliers - Finite sample effect

INDEX METHODS

Efficiency ranking of a set of WWTPs according to a composite index

- Set of 24 WWTPs from ENERWATER project. Different sizes and types.
- Three outputs (flowrate, COD removed, solids treated) and one input (energy)
- Ranking?
- Weights?

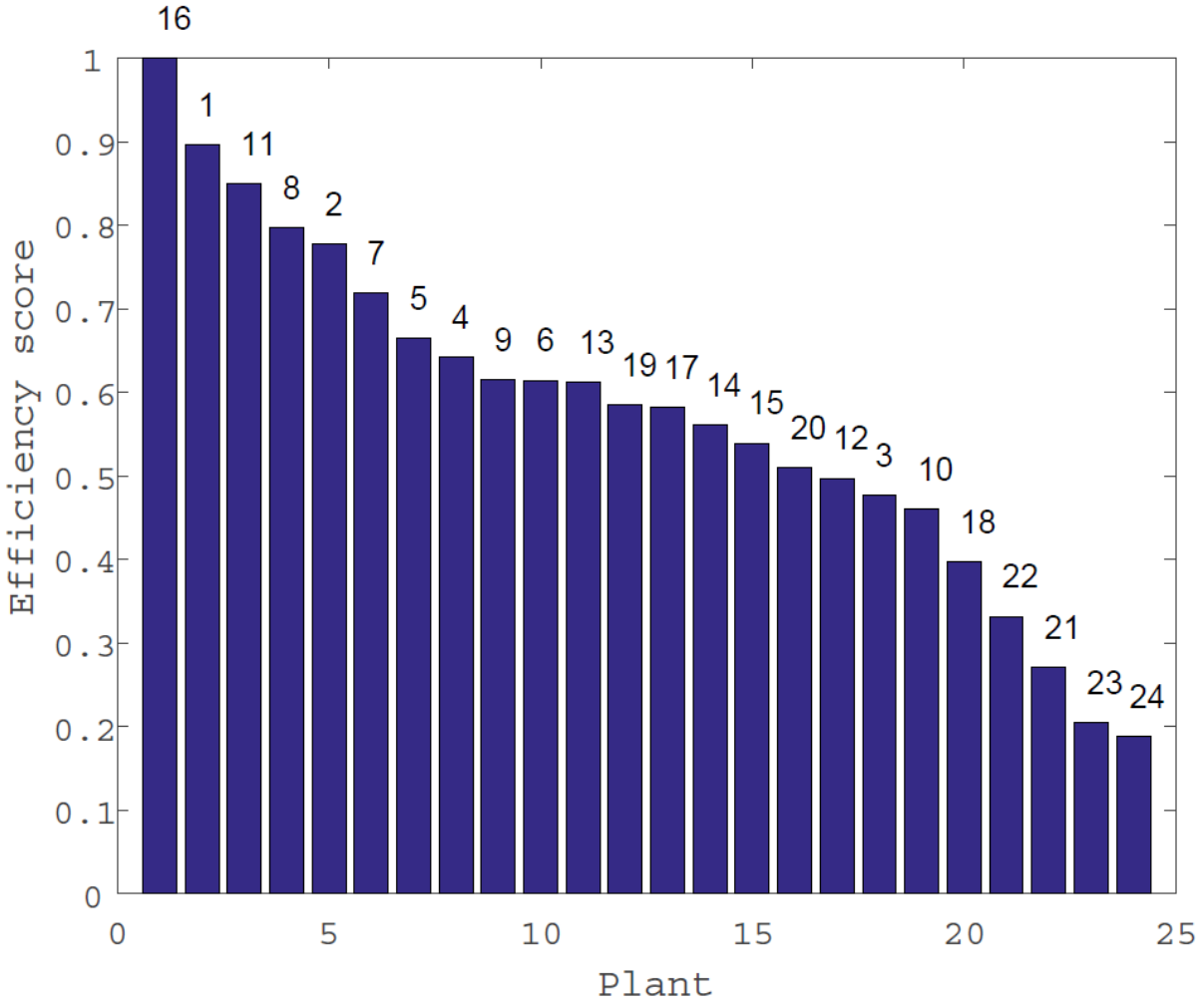


INDEX METHODS

Efficiency ranking of a set of WWTPs according to a composite index

- A composite index with the following weights:
  - 15% pumping
  - 74% COD removal
  - 11% sludge treatment

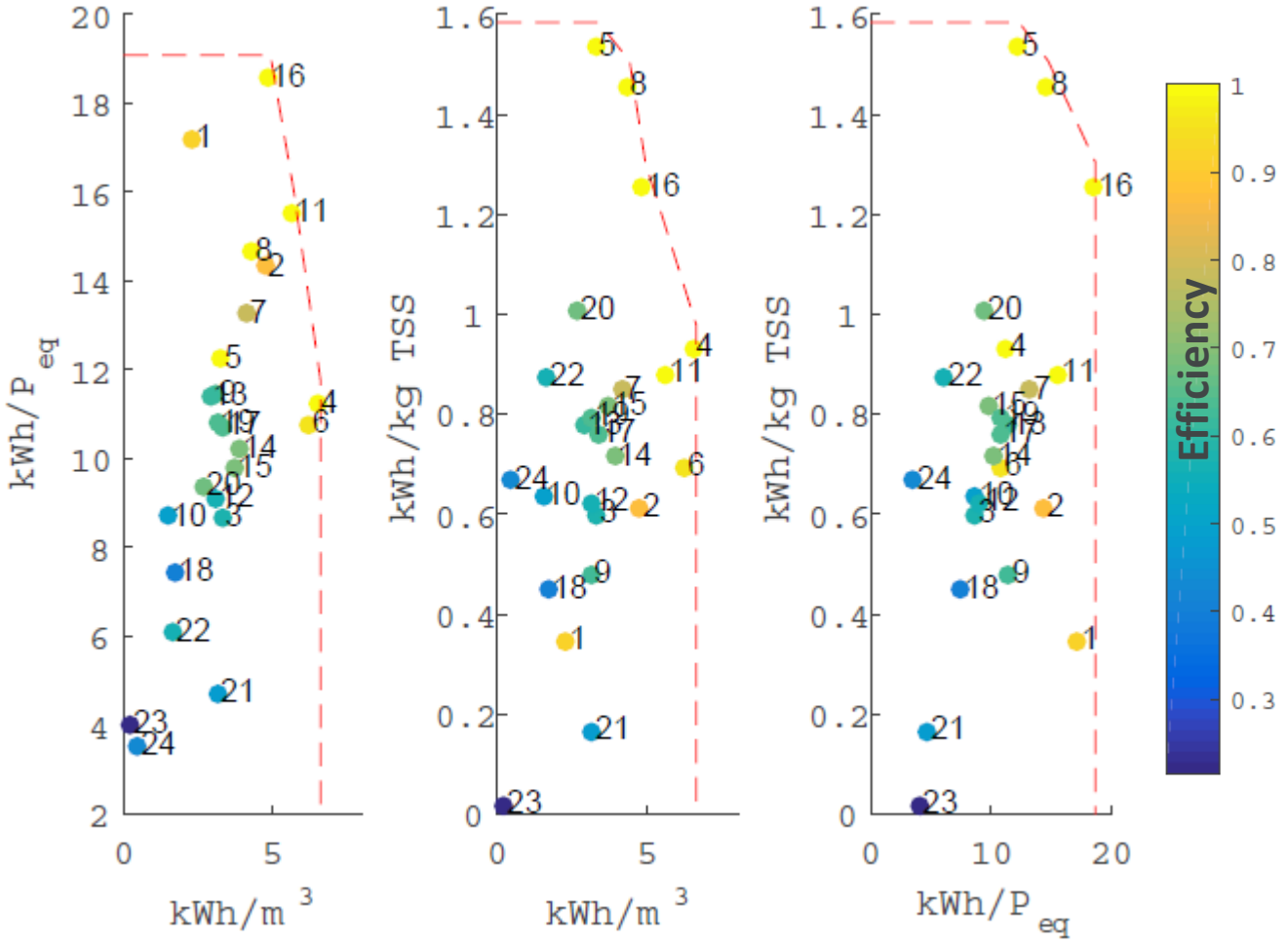
- Weights are arbitrary but **meaningful!**



DATA ENVELOPMENT ANALYSIS

Efficiency ranking of a set of WWTPs according to three output criteria

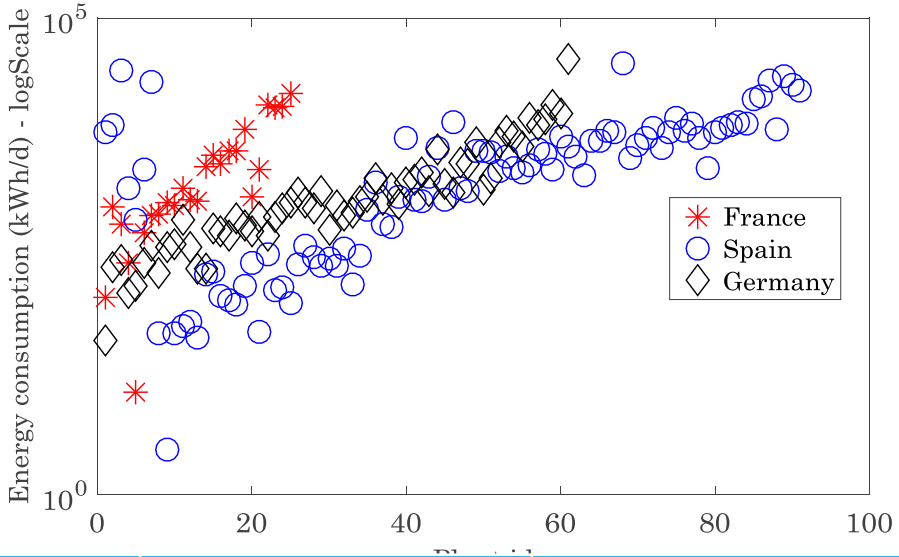
- Set of 24 WWTPs from ENERWATER project. Different sizes and types.
- DEA allows to reconcile multiple outputs with different units
- It is possible to rank the WWTP energy efficiency
- Applying weights is difficult. Diagnosis is not clear



REGRESSION METHODS

Does the country location impact the WWTP energy consumption?

- Set of 187 WWTPs with influent and effluent characteristics
- Differences persist as we control for more covariates
- No longer significant between Germany and Spain



	Germany	France	Spain
No control	-0.497*** (0.084)	0.614*** (0.157)	0.797***(0.110)
Log(F)	-0.425*** (0.059)	0.541*** (0.110)	0.680*** (0.077)
Log(F), CODinf	-0.300*** (0.065)	0.609*** (0.107)	0.416*** (0.099)
Log(F), CODinf, PLF	-0.270*** (0.063)	0.528*** (0.104)	0.378*** (0.095)
Log(F), CODinf, PLF, 2treat	-0.133 (0.155)	0.840*** (0.114)	0.003 (0.235)

REGRESSION METHODS

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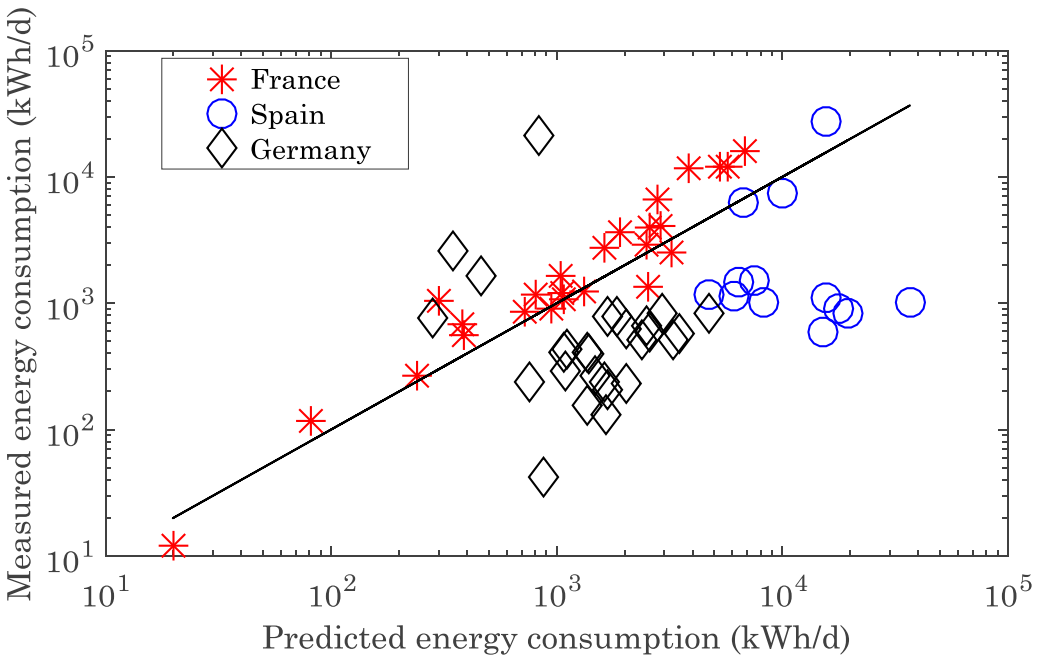

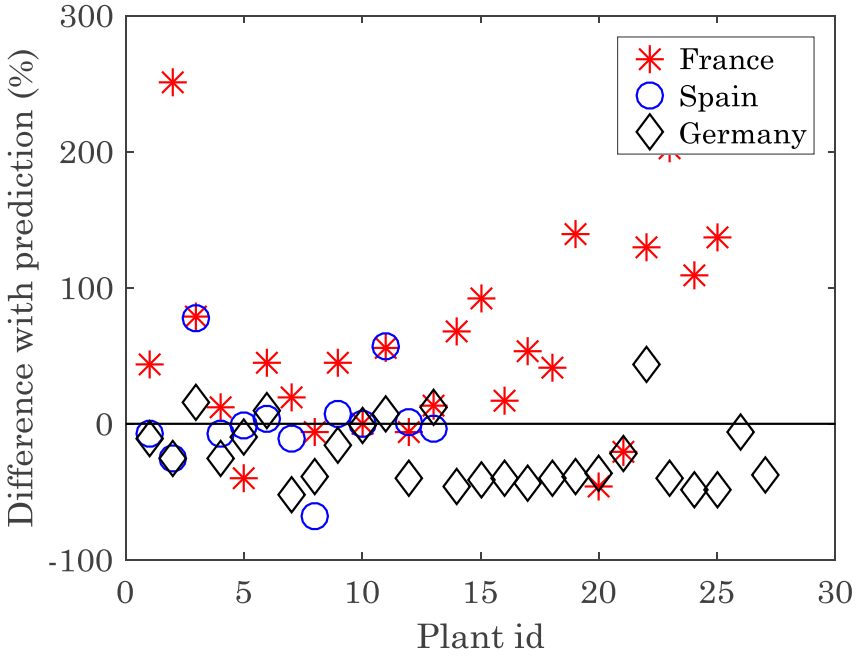

French WWTPs consume around 50% more energy than comparable German and Spanish WWTPs

CONCLUSIONS

- Simple index methods are very easy to understand and can be applied with flexibility(1. For multiple input/output evaluations they may require weights and/or data normalisation which may appear arbitrary.
- DEA is excellent for several input/outputs. It requires a homogeneous set of high quality data
- Regression methods are best suited for diagnosis and to cover the effect of exogenous variables. It requires a certain amount of data but it is less sensitive to outliers

1) Cabrera et al. 2016. Global Trends & Challenges in Water Science, Research and Management

TO KNOW MORE

Longo et al. 2016. Applied Energy, 179, 1251

Monitoring and diagnosis of energy consumption in wastewater treatment plants. A state of the art and proposals for improvement

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A STANDARD METHOD AND ONLINE TOOL FOR ASSESSING AND IMPROVING THE ENERGY EFFICIENCY OF WASTEWATER TREATMENT PLANTS

ENERWATER