KA AI Databygg - Trondheim, 25th of November

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### **Energy Consumption forecasting using ML-based model. A Toy Example**

Implication of use ML in a real project Massimiliano Ruocco, PhD

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- What is ML/AI etc.?
- ML in practice
- Energy Consumption Forecasting: Toy Example
- Summary



# What is ML/AI etc.?





#### ARTIFICIAL INTELLIGENCE Early artificial intelligence MACHINE stirs excitement. LEARNING Machine learning begins DEEP to flourish. LEARNING Deep learning breakthroughs drive Al boom. 1950's 1960's 1970's 1980's 1990's 2000's 2010's





#### Machine Learning Supervised Learning problem





## **Machine Learning in Practice**





#### Machine Learning in Practice ML in Industrial Setting - ML Lifecycle







# **Machine Learning in Practice**

**ML in Industrial Setting - ML Lifecycle** 















Time





#### ML is not magic - ML is Tedious ML experimentation needs support





# **Energy Consumption Forecasting**





# Given past weather data and past energy consumption data for the previous N hours, forecast the energy consumption for the next M hours







## **Weather Data Extraction**

#### **API from Meterologisk Institutt**







#### Current Task - Energy usage prediction Beddingen 16







## **Current Task - Energy usage prediction**

Energy consumption - Plot of the last 3 years data







#### **Current Task - Energy usage prediction** Energy consumption data + Weather Data

	air_temperature	dew_point_temperature	relative_humidity	sum_precipitation_amount_PT1H	surface_snow_thickness	energy_consumed
2018-01-26 13:00:00+00:00	0.428058	0.537778	0.785714	0.0	0.243243	0.446154
2018-01-26 14:00:00+00:00	0.437050	0.533333	0.738095	0.0	0.243243	0.446154
2018-01-29 18:00:00+00:00	0.347122	0.462222	0.857143	0.0	0.324324	0.353846
2018-01-29 19:00:00+00:00	0.361511	0.448889	0.761905	0.0	0.324324	0.323077
2018-01-29 20:00:00+00:00	0.383094	0.442222	0.666667	0.0	0.297297	0.307692
2021-08-31 19:00:00+00:00	0.624101	0.744444	0.702381	0.0	0.000000	0.030769
2021-08-31 20:00:00+00:00	0.624101	0.726667	0.654762	0.0	0.000000	0.015385
2021-08-31 21:00:00+00:00	0.622302	0.731111	0.666667	0.0	0.000000	0.015385
2021-08-31 22:00:00+00:00	0.624101	0.731111	0.666667	0.0	0.000000	0.015385
2021-08-31 23:00:00+00:00	0.616906	0.735556	0.702381	0.0	0.000000	0.015385





## **Correlation Analysis**

Heatmap of the correlation between air temperature and energy consumption







## **Current Task - Energy usage prediction**

Multi-Horizon Forecasting Problem - Prediction of Energy consumed in the next 12H







#### **Current Task - Energy usage prediction Forecasting Problem - Case 1**

energy\_consumed



018-01-30 00:00:00+00:00	0.400000
018-01-30 01:00:00+00:00	0.400000
018-01-30 02:00:00+00:00	0.353846
018-01-30 03:00:00+00:00	0.353846
018-01-30 04:00:00+00:00	0.369231
018-01-30 05:00:00+00:00	0.353846
018-01-30 06:00:00+00:00	0.323077
018-01-30 07:00:00+00:00	0.400000
018-01-30 08:00:00+00:00	0.492308
018-01-30 09:00:00+00:00	0.461538
018-01-30 10:00:00+00:00	0.461538
018-01-30 11:00:00+00:00	0.476923
018-01-30 12:00:00+00:00	0.430769
018-01-30 13:00:00+00:00	0.415385
018-01-30 14:00:00+00:00	0.369231
018-01-30 15:00:00+00:00	
018-01-30 16:00:00+00:00	
018-01-30 17:00:00+00:00	
018-01-30 18:00:00+00:00	
018-01-30 19:00:00+00:00	
018-01-30 20:00:00+00:00	
018-01-30 21:00:00+00:00	8
018-01-30 22:00:00+00:00	
018-01-30 23:00:00+00:00	
018-01-31 00:00:00+00:00	



air\_temperature energy\_consumed



## **Current Task - Energy usage prediction**

#### **Forecasting Problem - Case 2**



2018-01-30 00:00:00+00:00	0.379496	0.400000	
2018-01-30 01:00:00+00:00	0.384892	0.400000	Х
2018-01-30 02:00:00+00:00	0.384892	0.353846	
2018-01-30 03:00:00+00:00	0.392086	0.353846	
2018-01-30 04:00:00+00:00	0.386691	0.369231	
2018-01-30 05:00:00+00:00	0.383094	0.353846	
2018-01-30 06:00:00+00:00	0.395683	0.323077	
2018-01-30 07:00:00+00:00	0.393885	0.400000	
2018-01-30 08:00:00+00:00	0.386691	0.492308	
2018-01-30 09:00:00+00:00	0.383094	0.461538	
2018-01-30 10:00:00+00:00	0.415468	0.461538	
2018-01-30 11:00:00+00:00	0.415468	0.476923	
2018-01-30 12:00:00+00:00	0.424460	0.430769	
2018-01-30 13:00:00+00:00	0.417266	0.415385	
2018-01-30 14:00:00+00:00	0.411871	0.369231	
2018-01-30 15:00:00+00:00	0.401079	l.	
2018-01-30 16:00:00+00:00	0.393885	2	
2018-01-30 17:00:00+00:00	0.392086	9	
2018-01-30 18:00:00+00:00	0.386691		
2018-01-30 19:00:00+00:00	0.384892	28	
2018-01-30 20:00:00+00:00	0.307554		
2018-01-30 21:00:00+00:00	0.375899	4	Y
2018-01-30 22:00:00+00:00	0.390288		
2018-01-30 23:00:00+00:00	0.393885		
2018-01-31 00:00:00+00:00	0.356115		



air\_temperature energy\_consumed



## **Current Task - Energy usage prediction**

**Forecasting Problem - Case 3** 



2018-01-30 00:00:00+00:00	0.379496	0.400000	
2018-01-30 01:00:00+00:00	0.384892	0.400000	1
2018-01-30 02:00:00+00:00	0.384892	0.353846	
2018-01-30 03:00:00+00:00	0.392086	0.353846	
2018-01-30 04:00:00+00:00	0.386691	0.369231	
2018-01-30 05:00:00+00:00	0.383094	0.353846	
2018-01-30 06:00:00+00:00	0.395683	0.323077	
2018-01-30 07:00:00+00:00	0.393885	0.400000	
2018-01-30 08:00:00+00:00	0.386691	0.492308	
2018-01-30 09:00:00+00:00	0.383094	0.461538	
2018-01-30 10:00:00+00:00	0.415468	0.461538	
2018-01-30 11:00:00+00:00	0.415468	0.476923	
2018-01-30 12:00:00+00:00	0.424460	0.430769	
2018-01-30 13:00:00+00:00	0.417266	0.415385	
2018-01-30 14:00:00+00:00	0.411871	0.369231	J
2018-01-30 15:00:00+00:00	0.401079		
2018-01-30 16:00:00+00:00	0.393885	0	
2018-01-30 17:00:00+00:00	0.392086		
2018-01-30 18:00:00+00:00	0.386691		
2018-01-30 19:00:00+00:00	0.384892	20	
2018-01-30 20:00:00+00:00	0.307554	1	
2018-01-30 21:00:00+00:00	0.375899		Y
2018-01-30 22:00:00+00:00 🗙	2 0.390288		-
2018-01-30 23:00:00+00:00	0.393885		
2018-01-31 00:00:00+00:00	0.356115		













#### Prediction Example Case 3







#### Prediction Example Case 3







# Prediction Example







# Prediction Example











## **Summary**



- AI/ML is not magic!
- A lot of work to do in data preparation
- Need of testing several models
- Hyperparameter tuning is a tedious work
- Can we reuse same model for several building?
- How to use these predictions in a control system?

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Implication of use ML in a real project Massimiliano Ruocco, PhD

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Technology for a better society