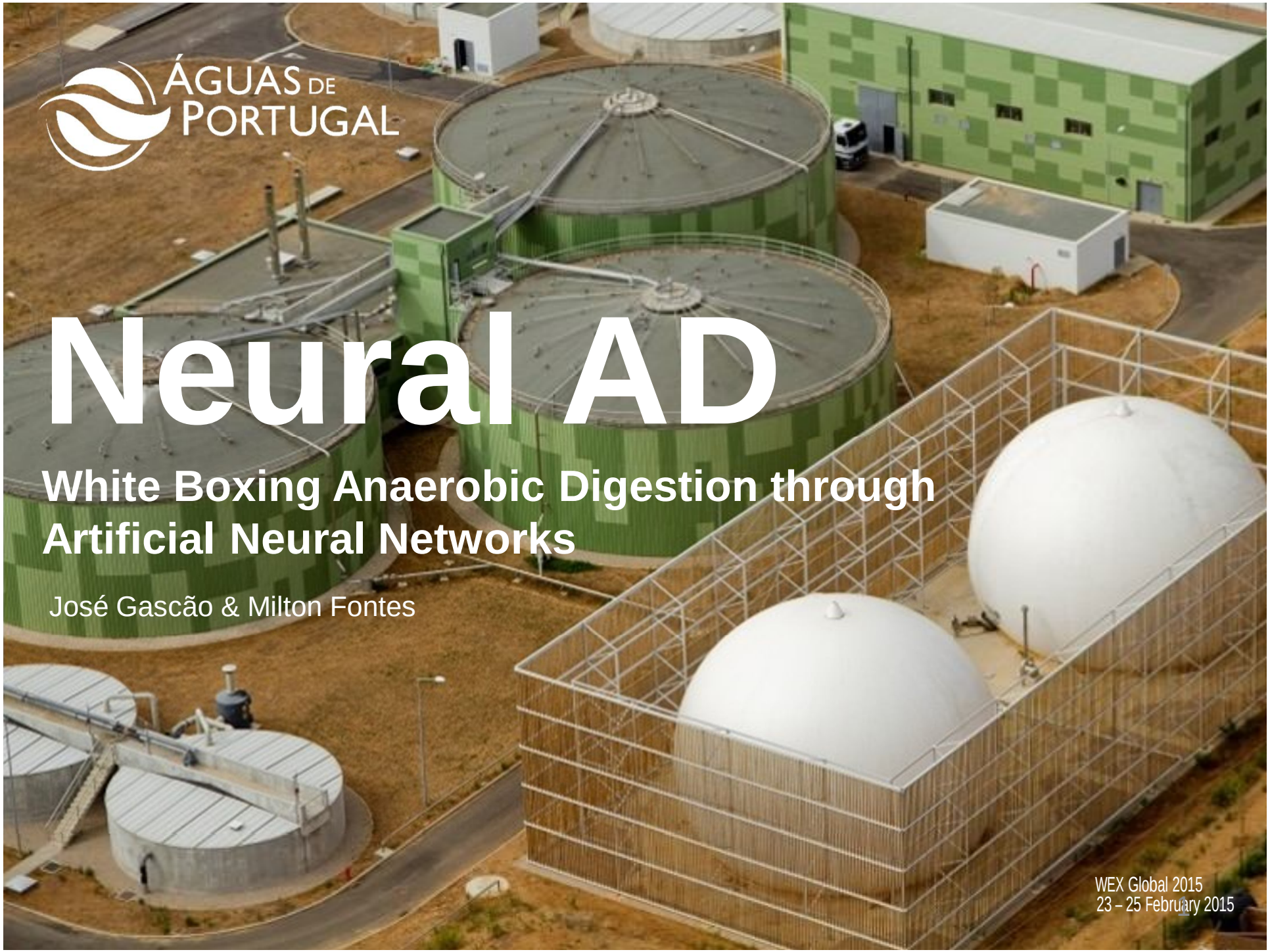


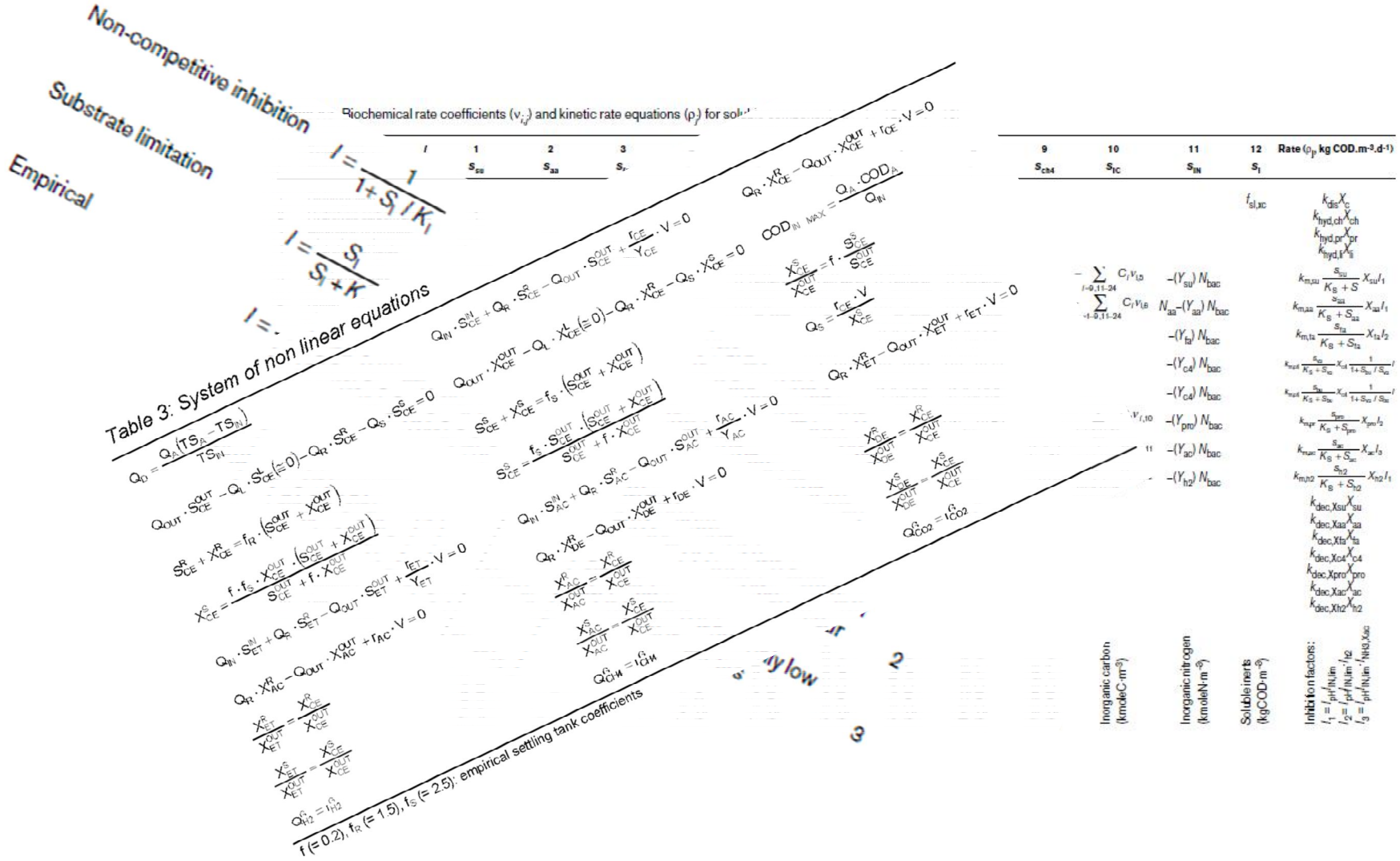
Neural AD

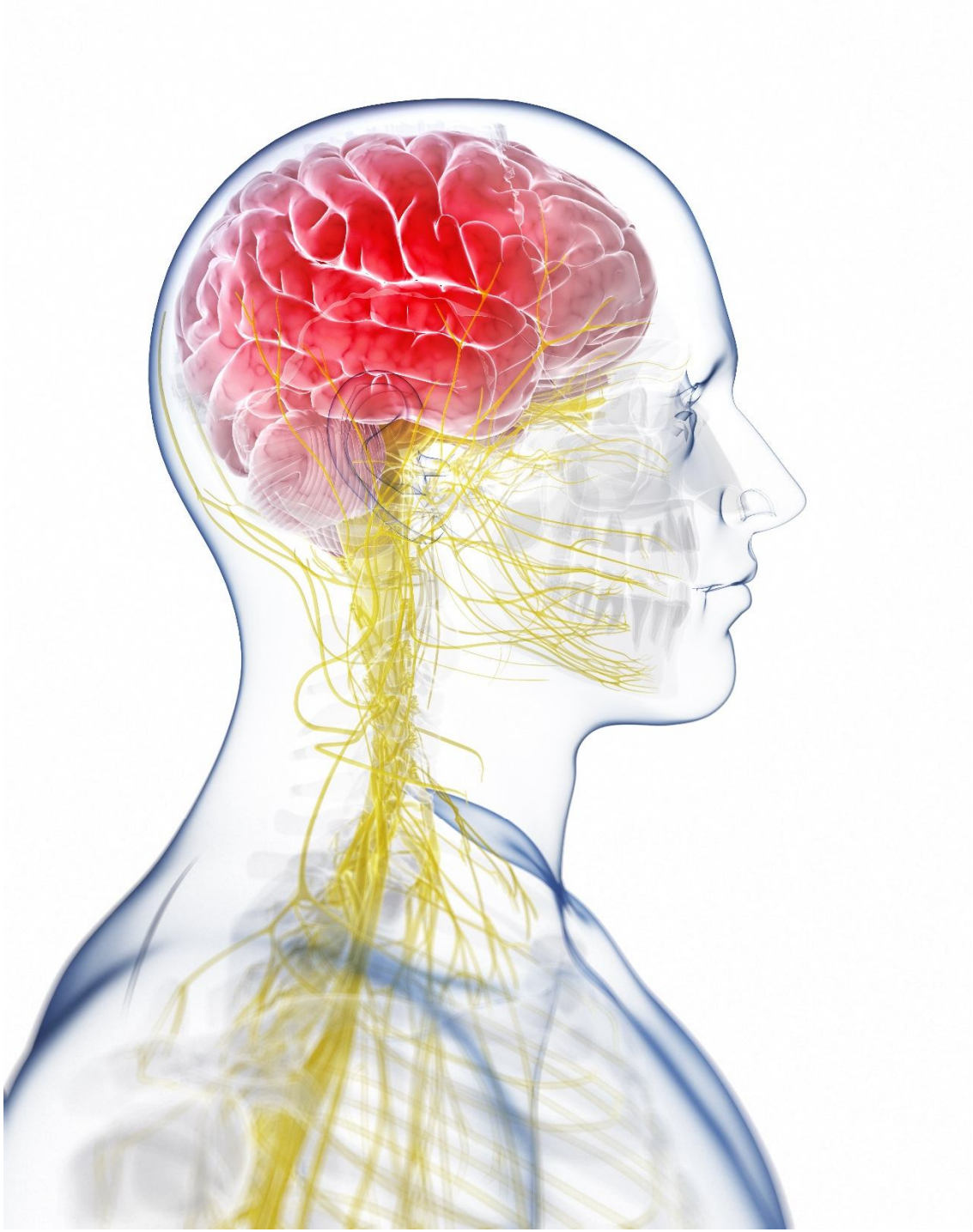
White Boxing Anaerobic Digestion through Artificial Neural Networks

José Gascão & Milton Fontes

Let’s model AD!

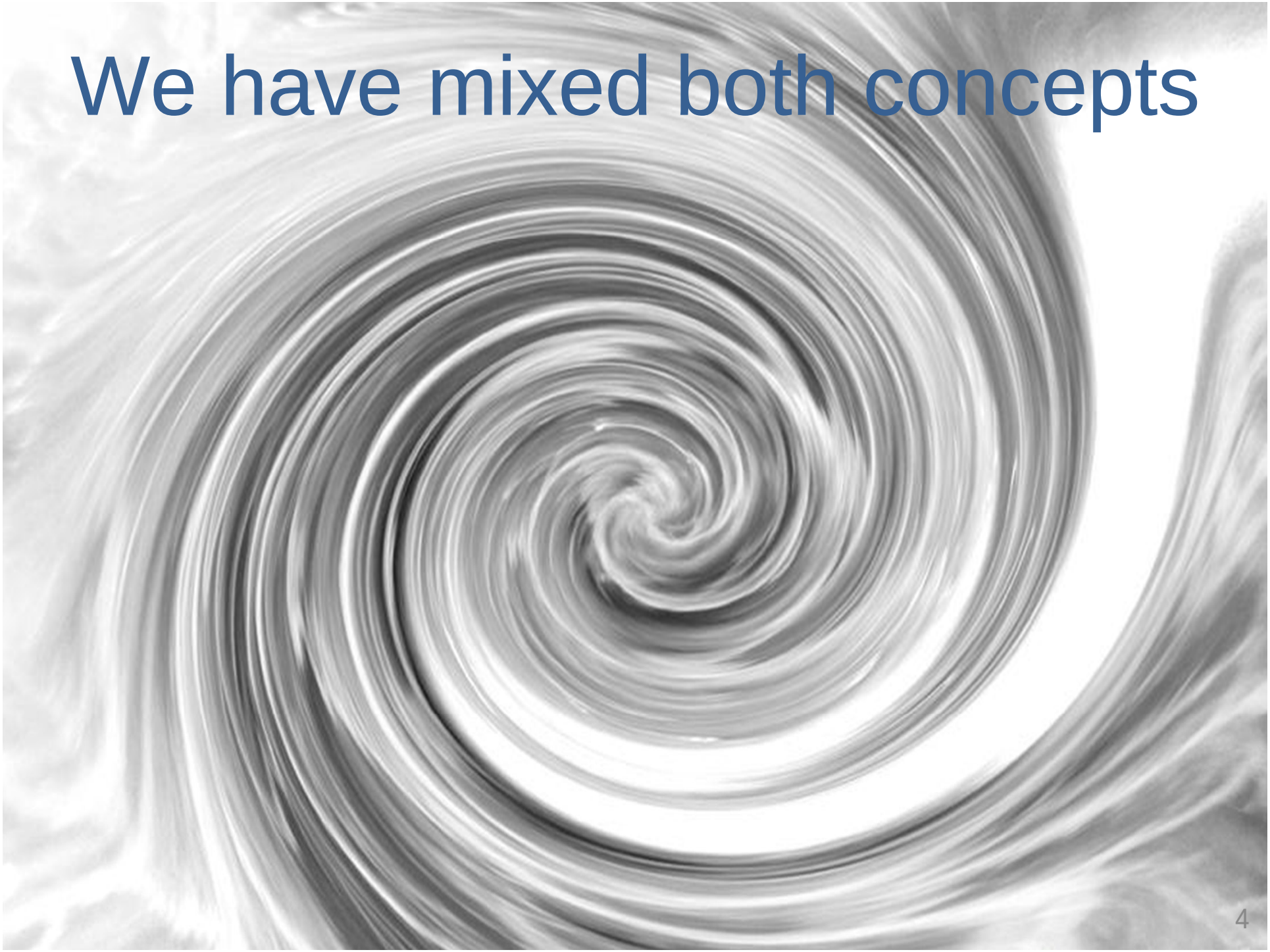
1st choice: traditional models (ADM1…)





But... How Does Human Brain Learn?

We have mixed both concepts



Our key figures

8 M PE served (Water & Wastewater)

More than 30 Anaerobic Digestions (AD)

Overall capacity ~ 160,000 m^3

More than 20 WWTP with CHP

Maximum energy production potential ~ 110 GWh/yr

Energy production in 2013 ~36 GWh

Investment ~ 50 M€

Available capacity

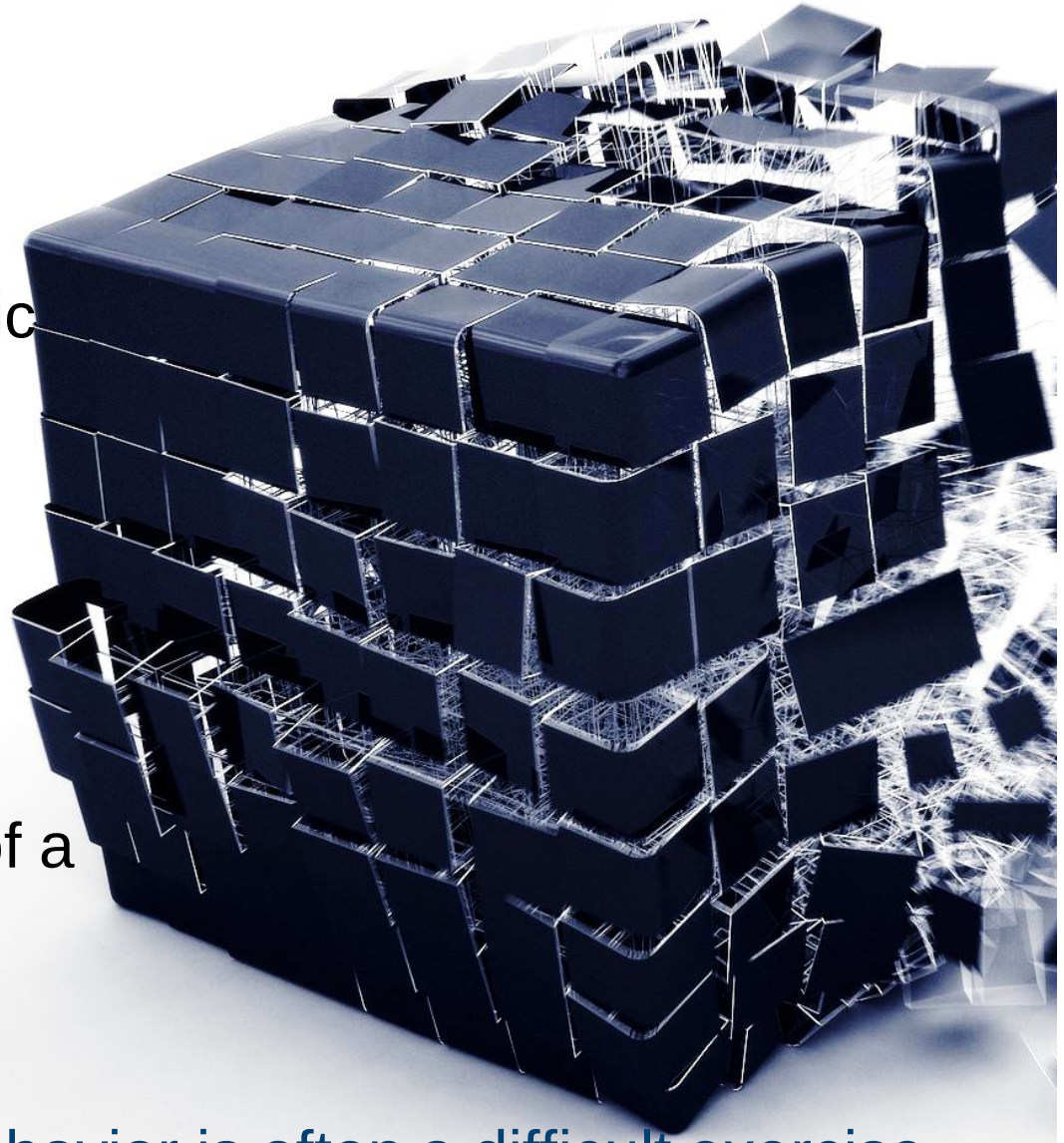
The Biogas production black box

A complex system

Lag: 15 to 25 days Hydraulic Retention Time

Cause-effect relationships difficult to establish

Uncertainty on the effects of a given change



Prediction of an AD plant behavior is often a difficult exercise

Our drive

WWTP Economic sustainability needs

- Less energy consumption in the treatment process
- More energy production from sewage

Biogas conversion to electricity

(and heat)

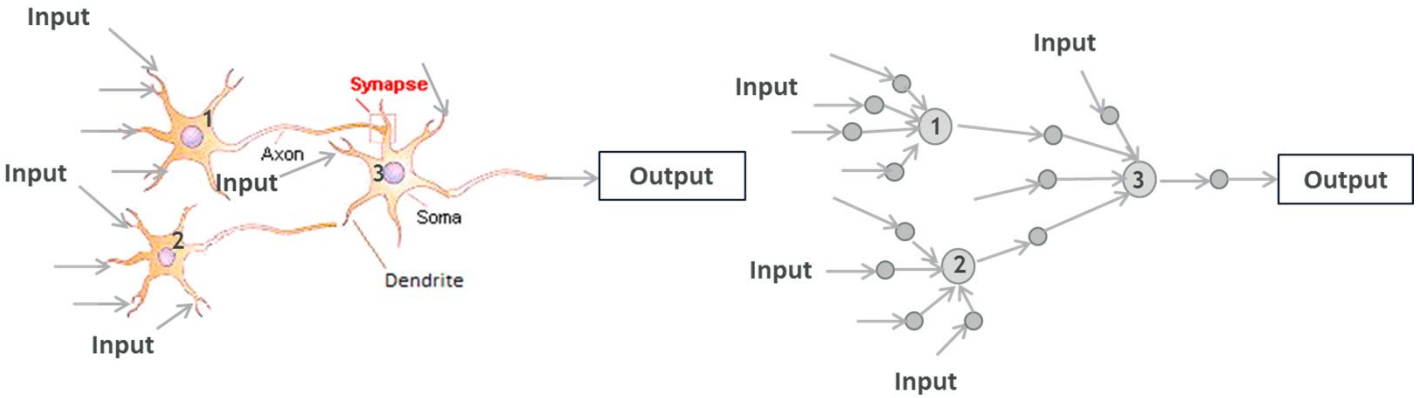
Innovative tools to help improve biogas production

Artificial Neural Networks

Linear models have proven difficult to apply to such a complex process like AD

ANN: Computational mathematical models

inspired in human brain



Data preparation

Training (80% of data)

Testing (20% of data)

Predicting (new data)

ANN: a watch-and-learn process

Neural AD development

FEED VOLATILE SOLIDS (VS)

FEED DRY SOLIDS (DS)

MODEL THE ANN USING ALL AVAILABLE INPUTS

ELIMINATE LESS SIGNIFICANT INPUTS

ORGANIC LOADING RATE

HIDRAULIC RETENTION TIME

MODEL THE ANN WITH DIFFERENT COMBINATIONS OF INPUTS

FEED VOLUME

DIGESTER TEMPERATURE

Neural AD so far

6 different WWTP

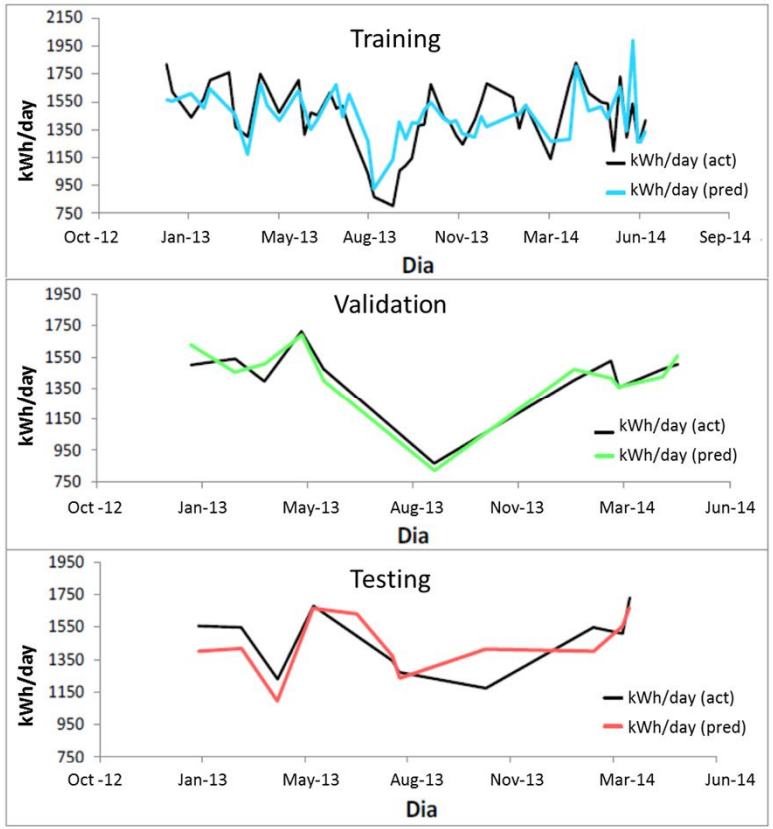
- Ave (6,000 m^3 / 800 kW)
- Norte (13,000 m^3 / 720 kW)
- Sul (6,000 m^3 / 660 kW)
- Vila Franca (1,800 m^3 / 175 kW)
- Guia (21,500 m^3 / 2,900 kW)
- Seixal (4,000 m^3 / 350 kW)

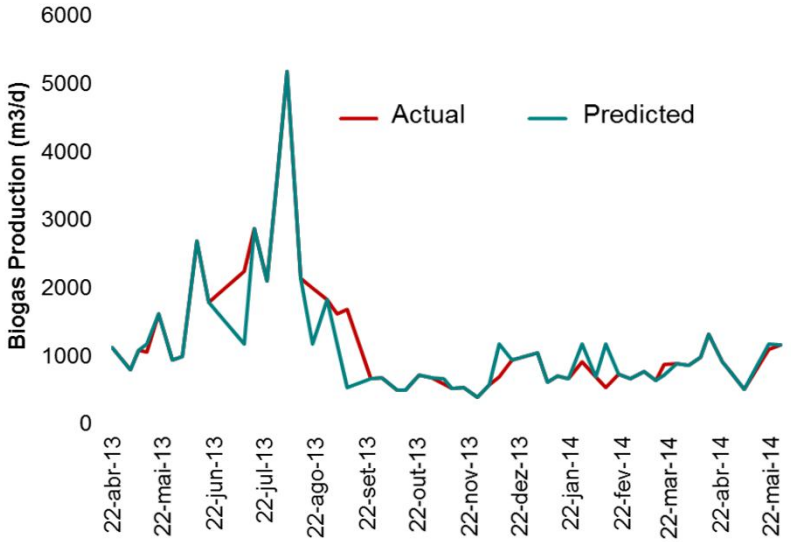
2 years (2013 and 2014)

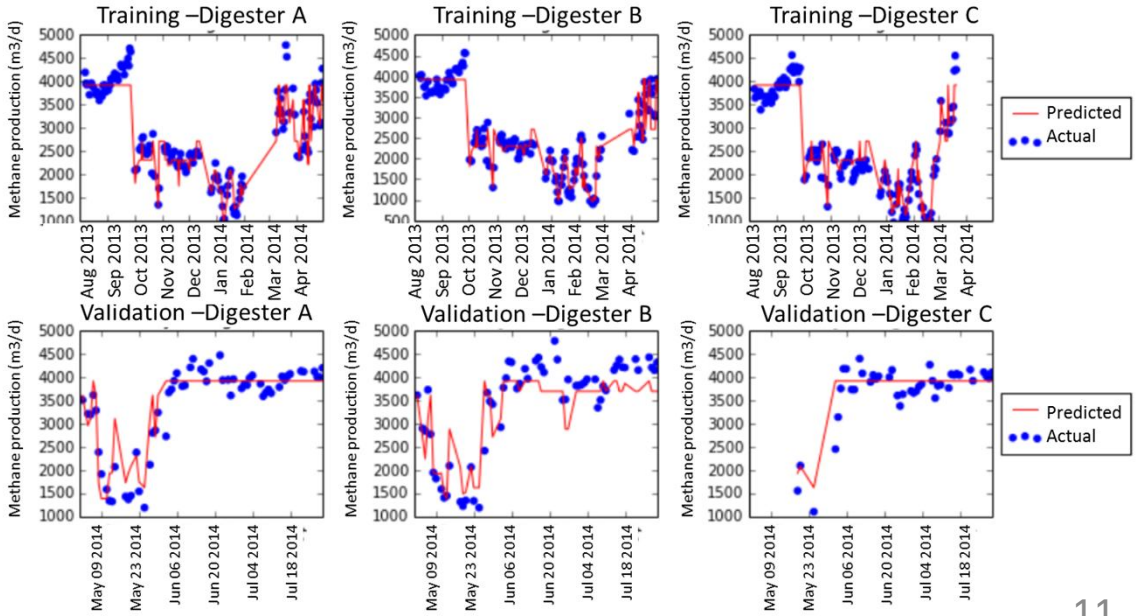
3 different support softwares

4 Universities

Neural AD Outputs







Different Outputs

- Electrical production
- Biogas Production
- Methane Production

Our Achievements

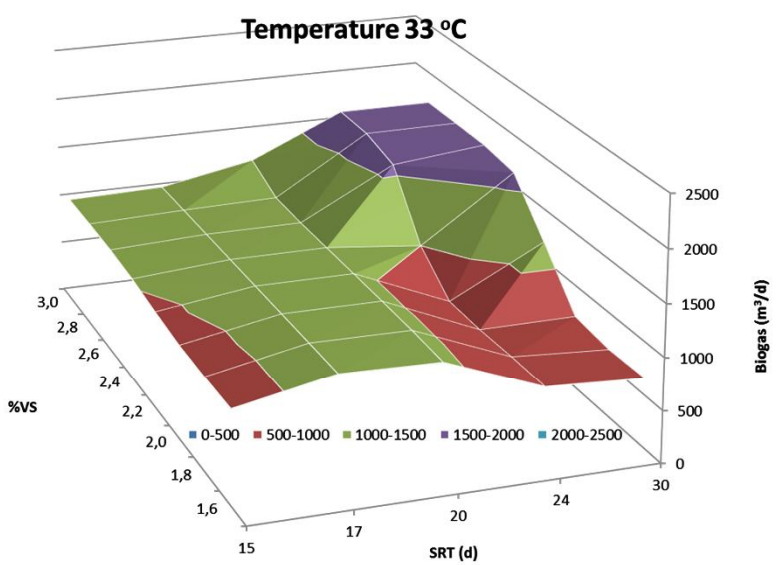
Good prediction accuracy

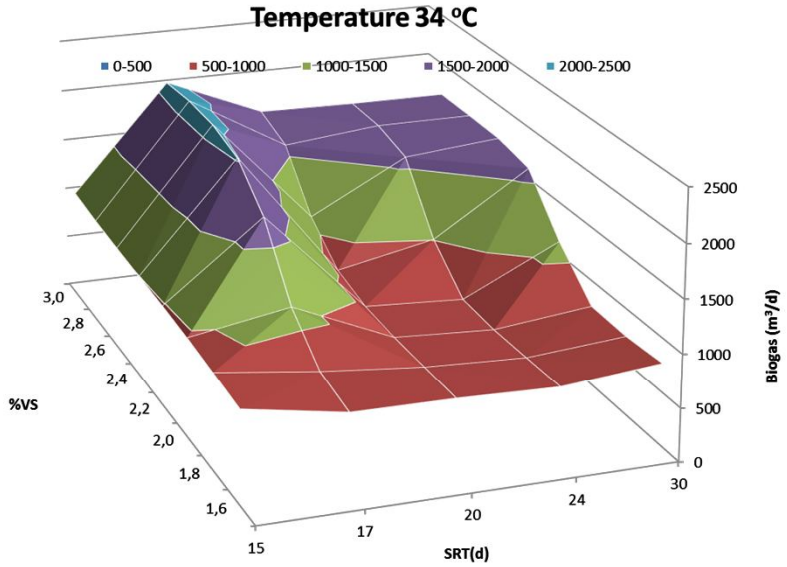
Few input variables needed

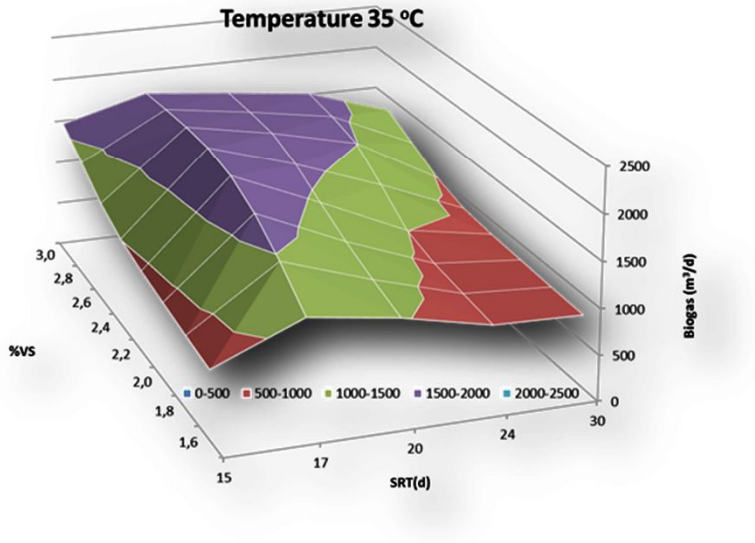
More focused WWTP's analytical plans

Increased and stabilized biogas production

Neural AD Quick Decision Tools





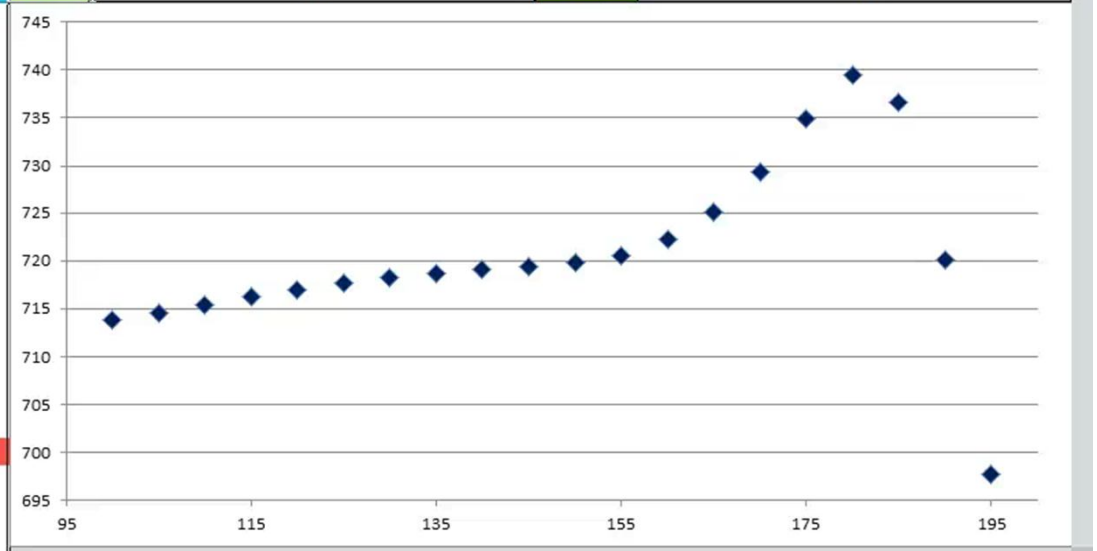


Neural AD Quick Decision Tools

FEED VOLATILE SOLIDS (%VS)	DAILY FEED VOLUME (m3)	DIGESTER TEMPERATURE (ºC)	ORGANIC LOADING RATE (kgVS/m3.d)	DAILY BIOGAS PRODUCTION (m3)
SL4 %MV	Q_{ent} (m^3)	Temp. (°C)	CMV	$Q_{biogás}$ (m^3)
1,6	100	34,4	0,53	714
1,6	105	34,4	0,56	715
1,6	110	34,4	0,59	715
1,6	115	34,4	0,61	716
1,6	120	34,4	0,64	717
1,6	125	34,4	0,67	718
1,6	130	34,4	0,69	718
1,6	135	34,4	0,72	719
1,6	140	34,4	0,75	719
1,6	145	34,4	0,77	719
1,6	150	34,4	0,80	720
1,6	155	34,4	0,83	721
1,6	160	34,4	0,85	722
1,6	165	34,4	0,88	725
1,6	170	34,4	0,91	729
1,6	175	34,4	0,93	735
1,6	**180**	34,4	**0,96**	**740**
1,6	185	34,4	0,99	737
1,6	190	34,4	1,01	720
1,6	195	34,4	1,04	698

DAILY BIOGAS PRODUCTION (m3)

SL4 %MV: 1,6 | TEMP. (ºC): 34,4



Next Steps

Application in other WWTP

Expansion of current datasets

Establish a common methodology to:

- Determine correct input variables
- Data treatment
- Finding the best ANN

PRODUCT:

Neural AD – a control panel for plant operators

Thank you, Partners!

The AdP Group Companies and their experts involved in Neural AD

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