

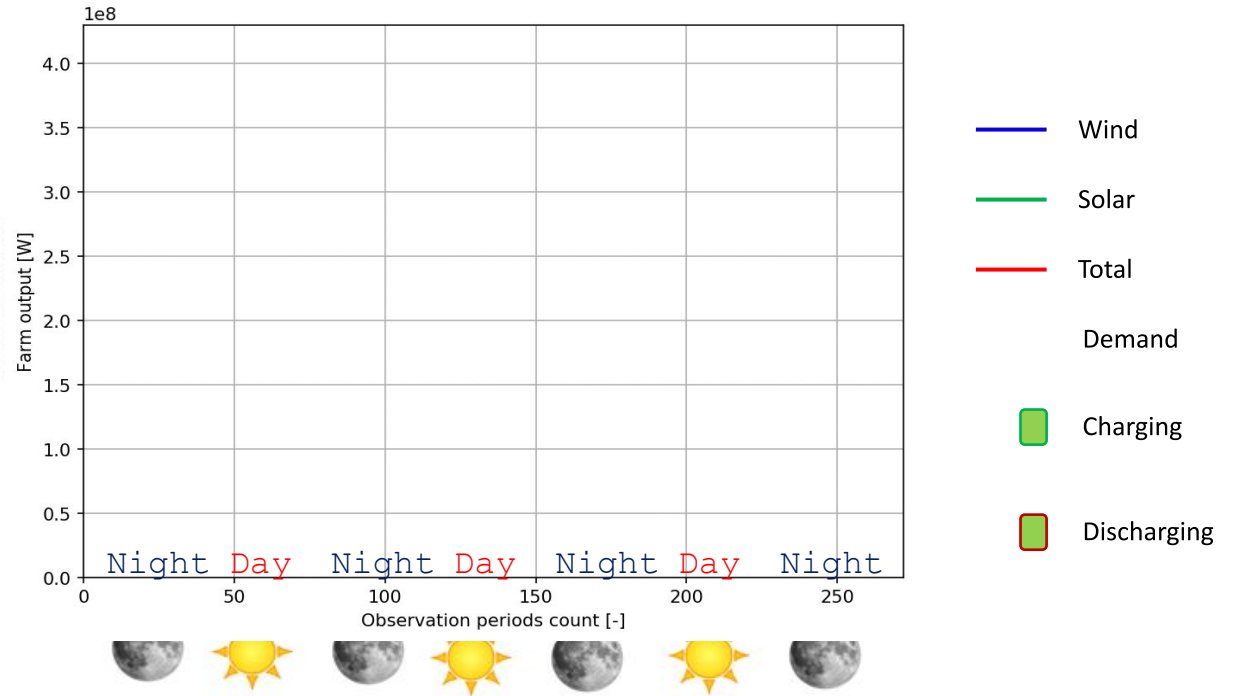
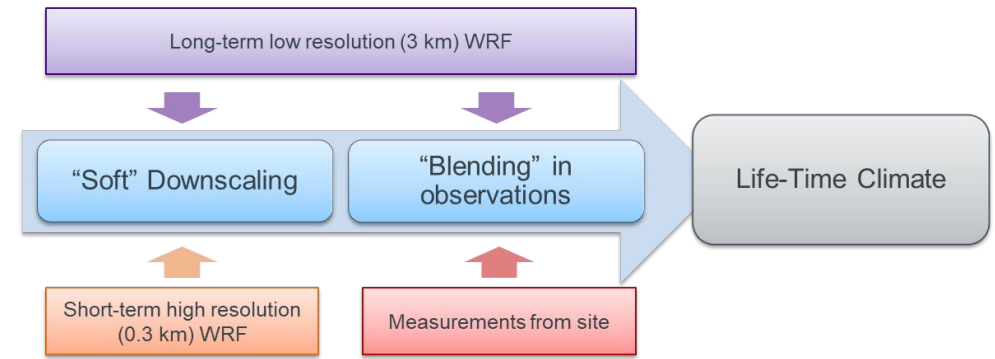
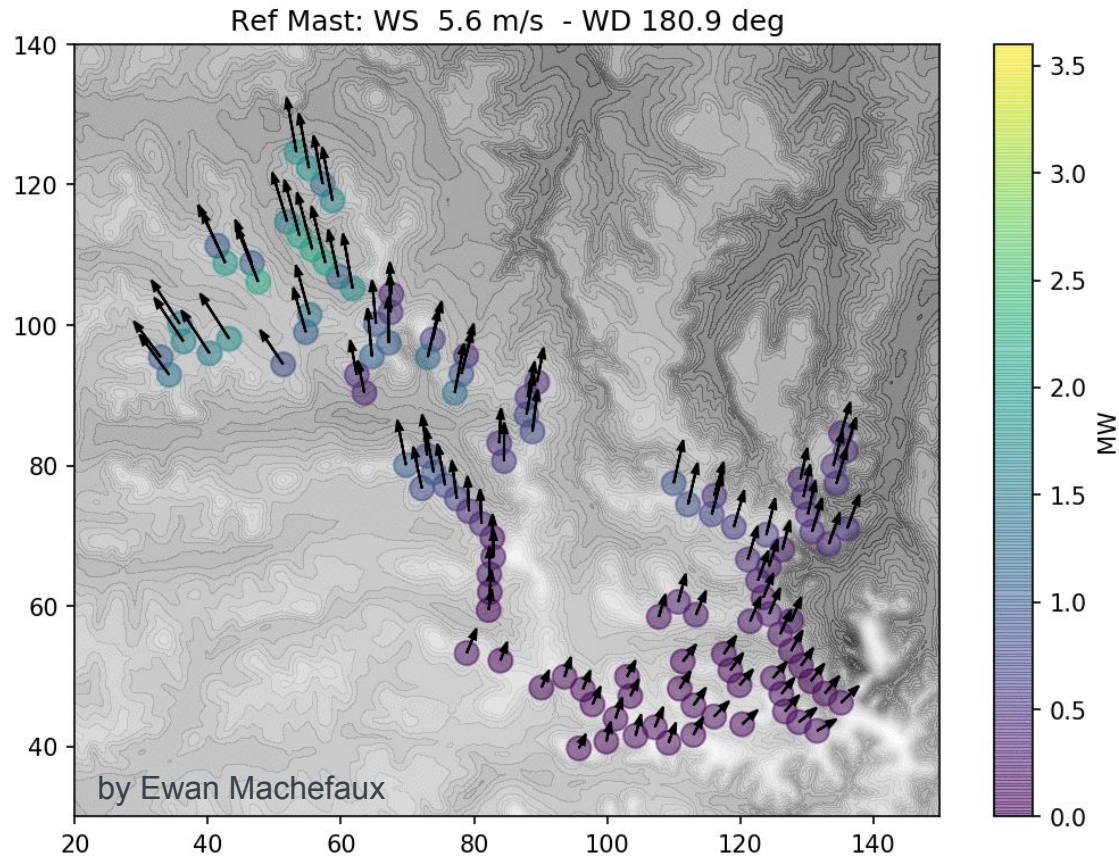
# High fidelity simulations and uncertainty

Mark Žagar

Plant & Hybrid Solutions



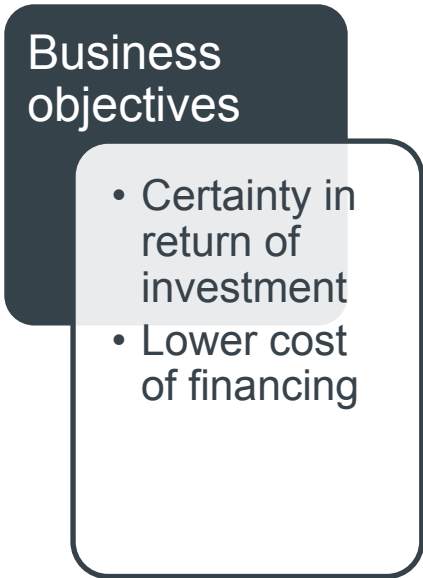
# Hybrid plant simulations for energy output



- Timing of energy □ demand, price
- Sizing of storage
- Managing component degradation effect

# Managing production uncertainty for business certainty

5-10-year, atmospheric modelling perspective



**Business objectives**

- Certainty in return of investment
- Lower cost of financing

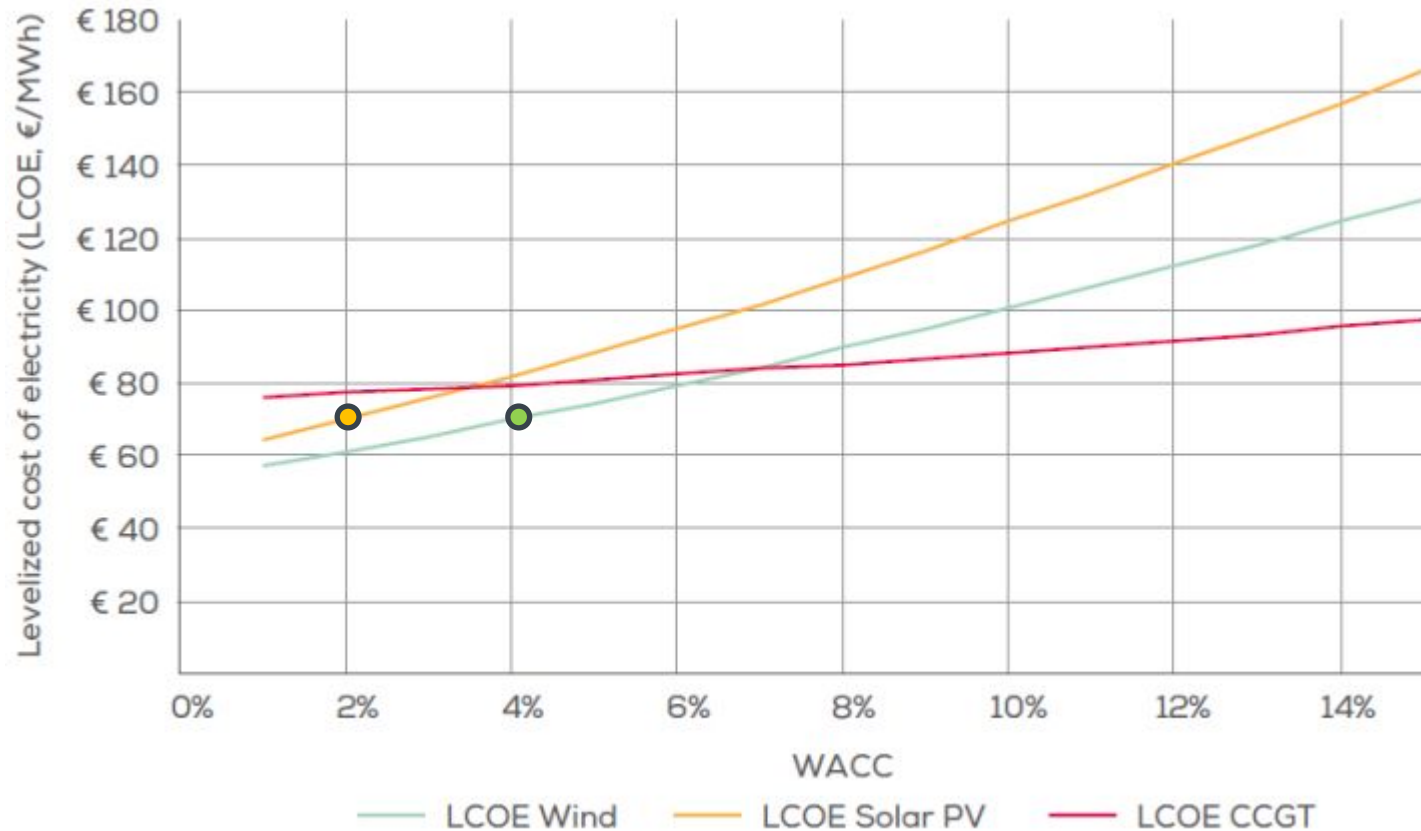
**Knowing the customer**

# Price of uncertainty

$$\text{LCoE [€/MWh]} = \frac{\text{CAPEX}_{(L)} + \text{OPEX}_{(L)}}{\text{Energy}_{(L)}}$$

OPEX (Operational expenses): Service

CAPEX (Capital expenses): WTG + Financing



Financing cost depends on the **perceived risk**.  
It is higher for **wind** than for **PV**.

**WACC**: weighted average cost of capital

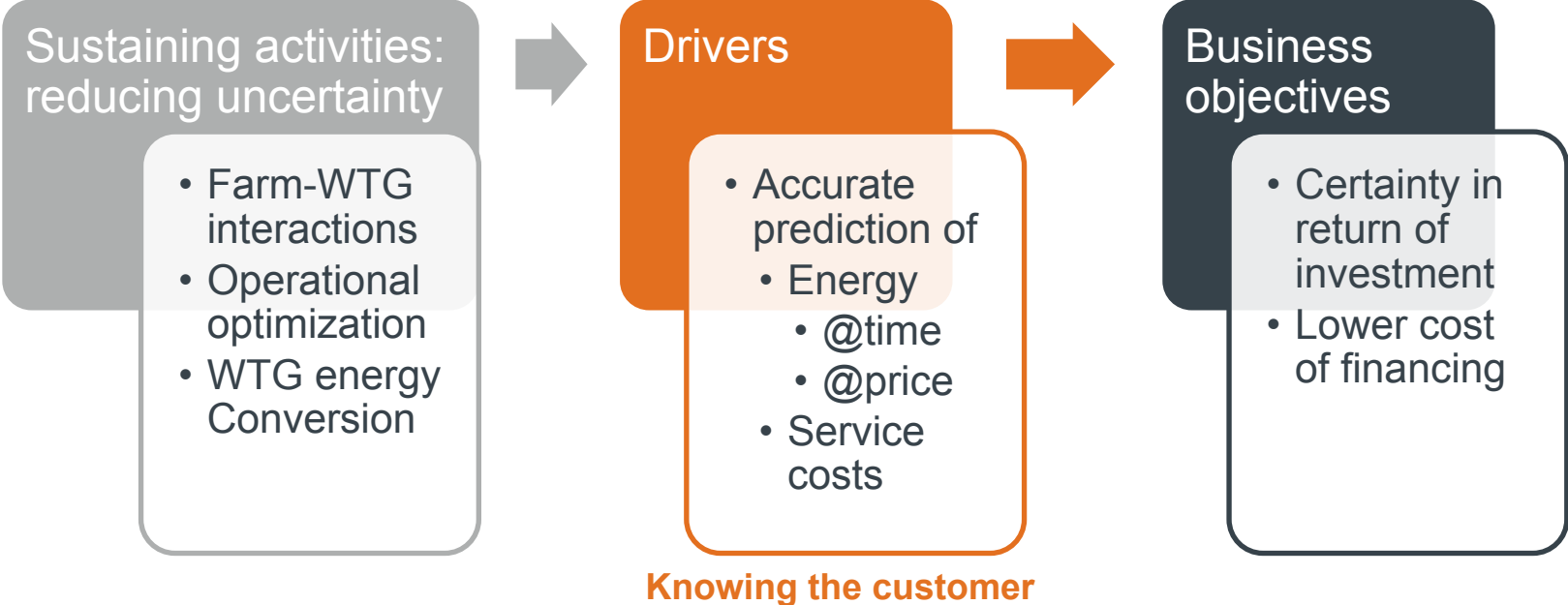
Loan interest  $XYZ_*$

**WACC**

$$\text{WACC} = \text{Cost of Equity} * \% \text{Equity} + \text{Cost of Debt} * \% \text{Debt} * (1 - \text{Tax Rate}) + \text{Cost of Preferred Stock} * \% \text{Preferred Stock}$$

# Managing uncertainty for business certainty

5-10-year, atmospheric modelling perspective



# Energy conversion

“Power curve”

## Challenge:

Understanding the WTG **response** to any state of the atmosphere

so that

The performance **can be predicted**

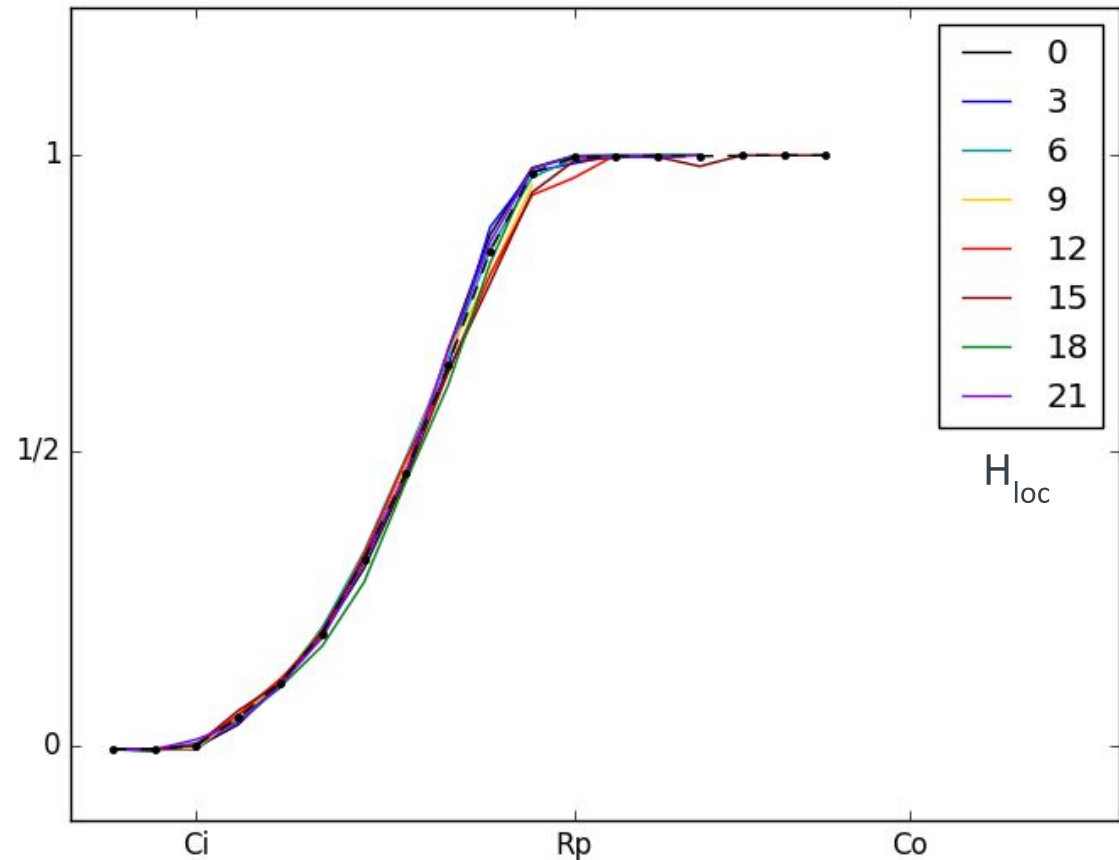
- HH wind speed
- Rotor-averaged wind speed
- Shear
- Turbulence intensity
- Veer
- ...

5D  $\mu$ Climate

*Power curve verification setup*

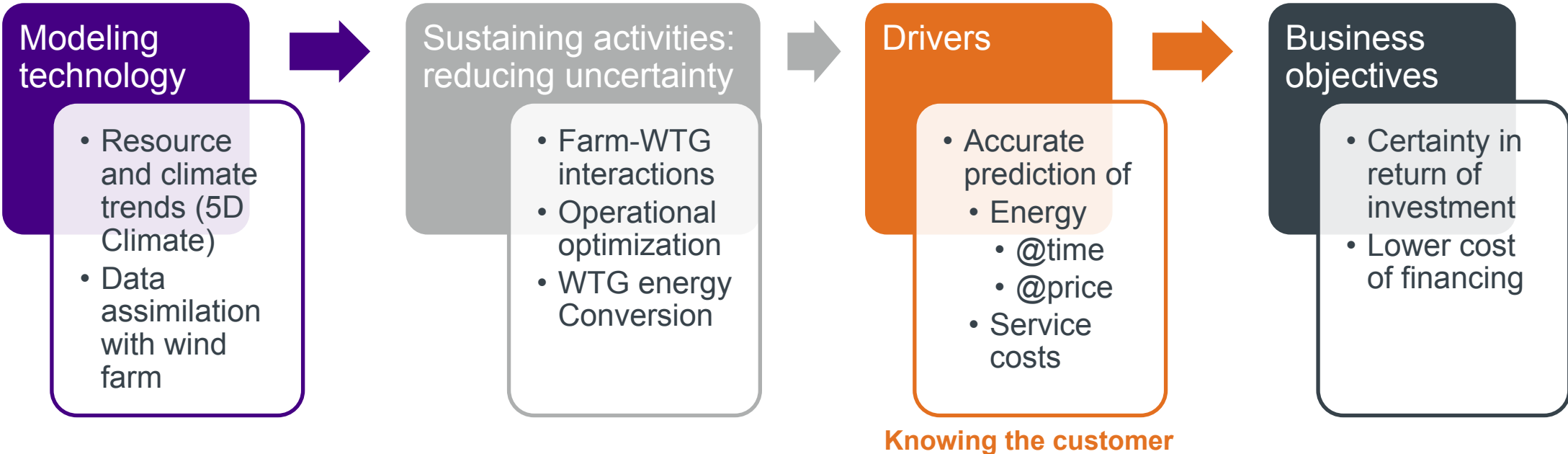


Empirical power curve vs. Local time



# Managing uncertainty for business certainty

5-10-year, atmospheric modelling perspective



The End

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