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GUROBI OPTIMIZATION | PREMIER PARTNER

- Introduction Decide4AI
- Use Case examples:
    - Detailed necessity: Optimization of electric cable lay out of wind farms
    - Customer idea: Optimization of maintenance of windmill turbines
- Opportunity evaluation methodology

About Decide4AI

Specialist consultants in AI/DI since 2008:

- Mathematical Optimization / Decision Intelligence
- Data Science

Premier Gurobi Partner

Madrid & Utrecht

150 employees

Arjen Heeres

CEO

Dani Herrero

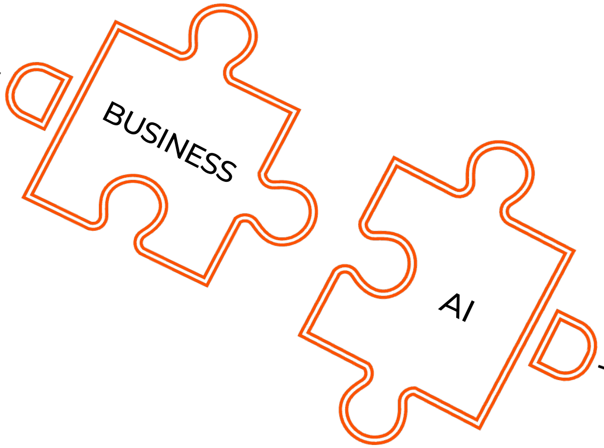
Dir. Mathematical Optimization & Data Science

We Make AI / DI Work

IT / Cloud
Architects and Data
Management

Data
Science

Mathematical
Optimization



Electrical Layout Design of an Offshore Wind Farm

Layout design of offshore wind power generation facilities

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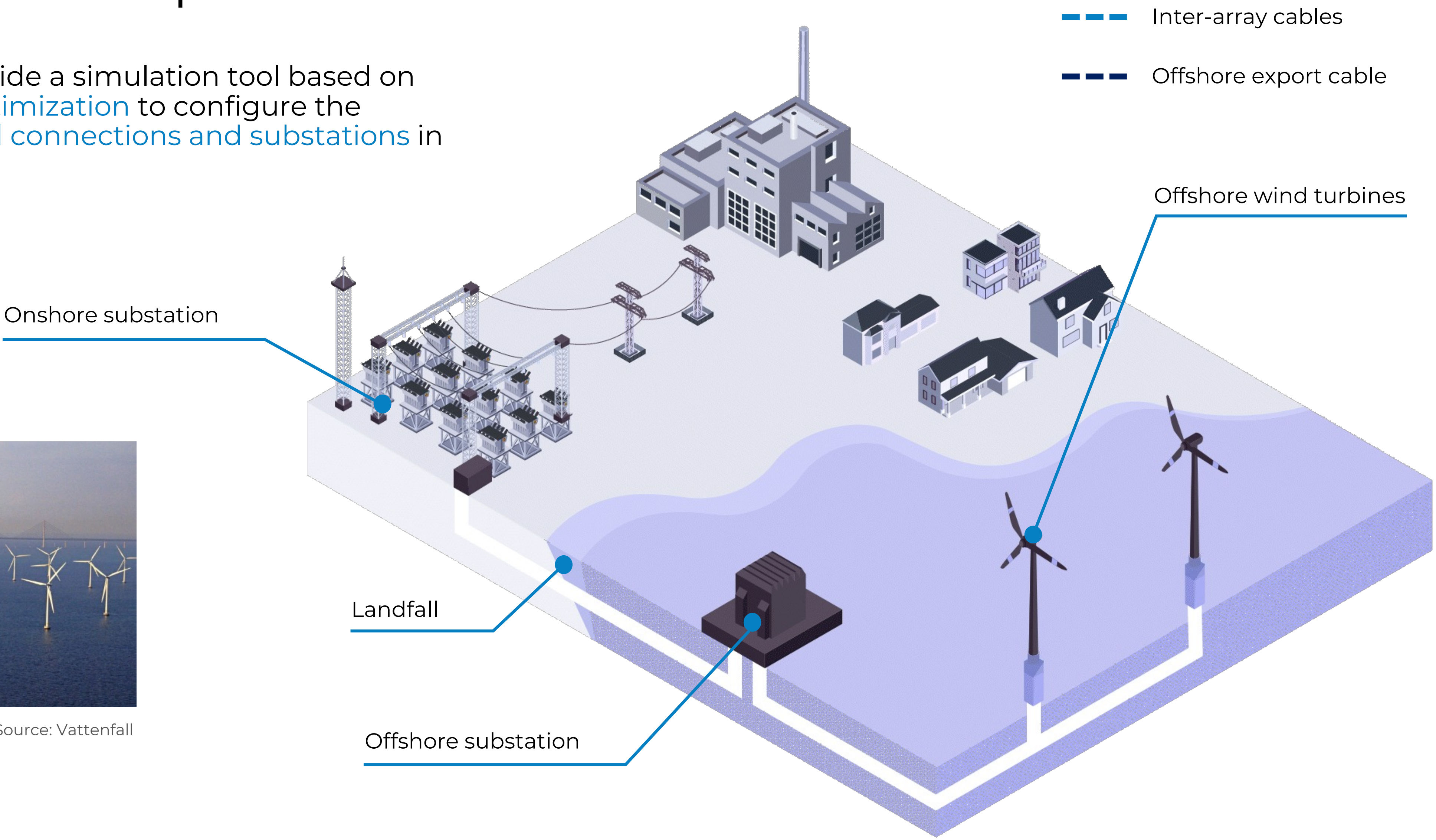
Problem description

Objective: To provide a simulation tool based on mathematical optimization to configure the layout of electrical connections and substations in wind farms.

Denmark offshore wind farm. Source: Vattenfall



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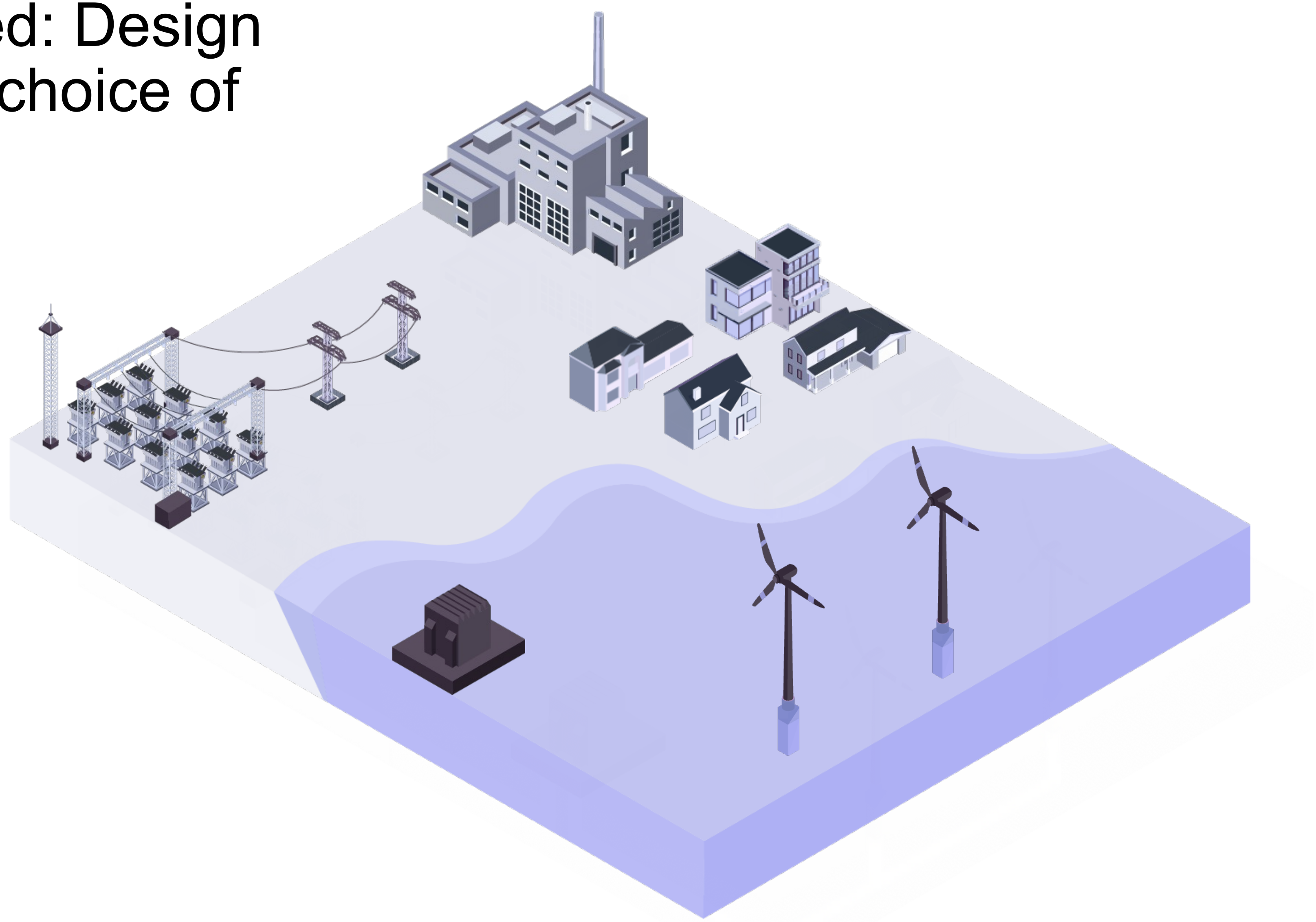
Problem to be solved: Design of connections and choice of cable types

Decisions



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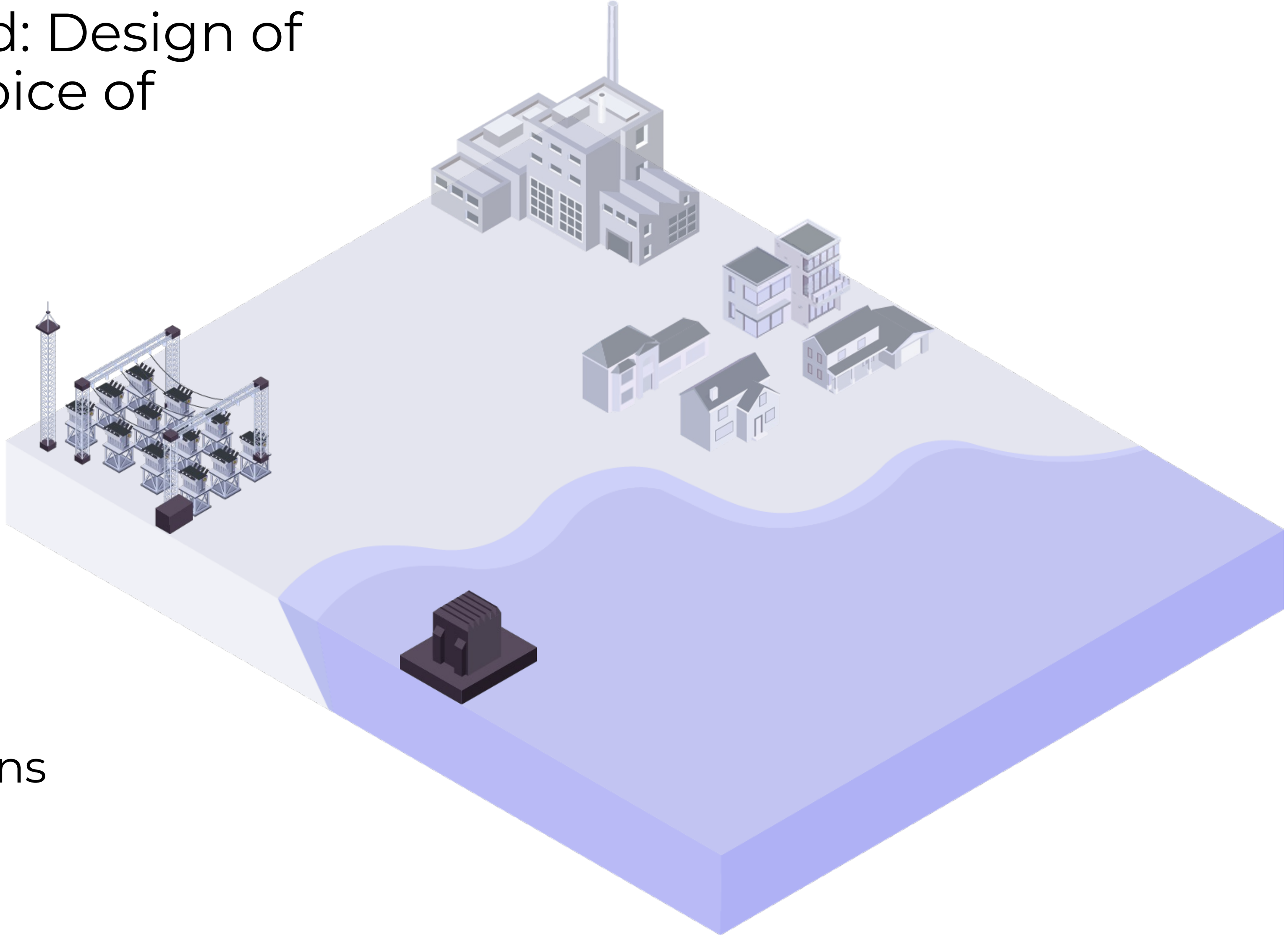

1. Positioning of substations

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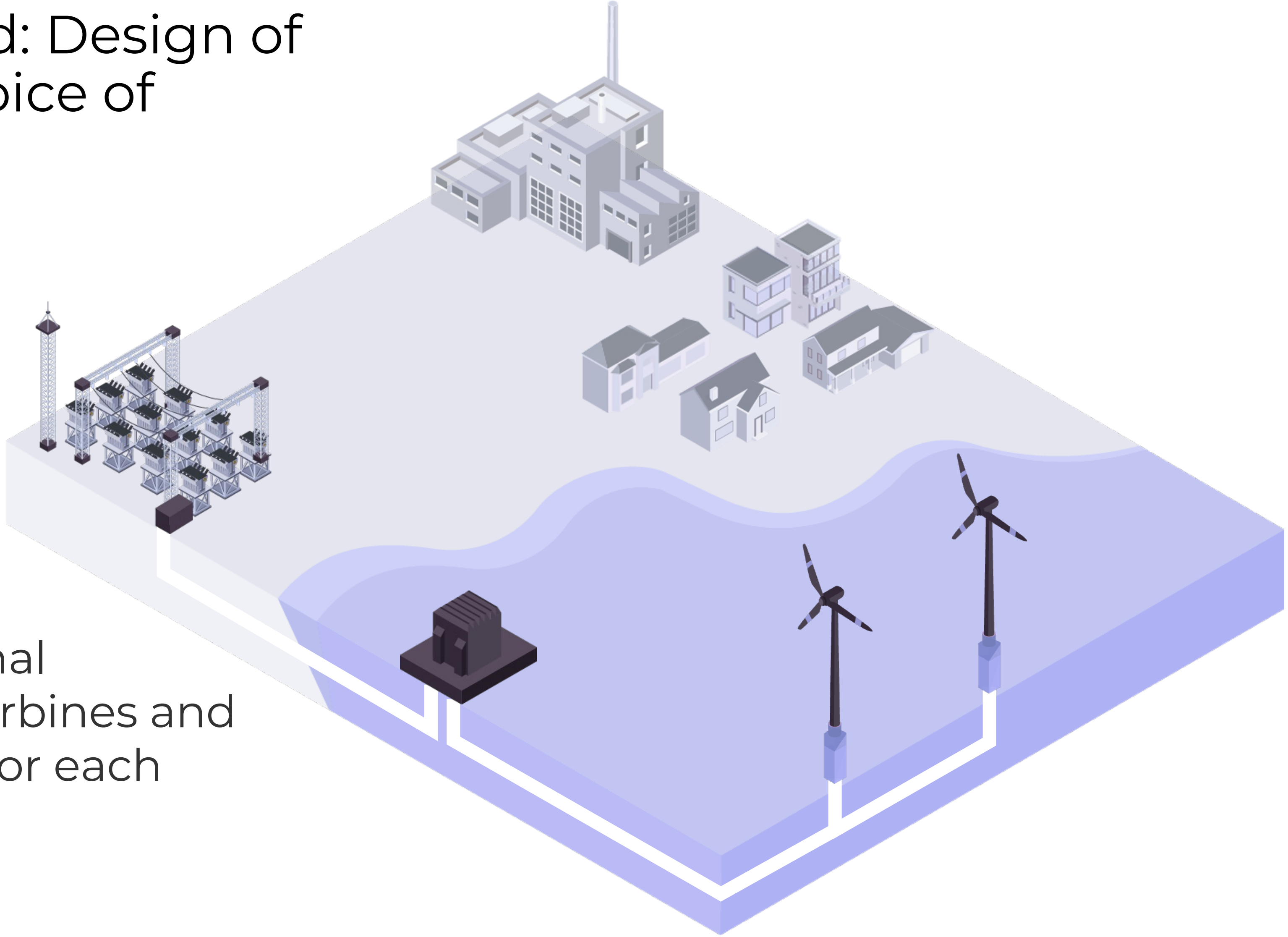
Problem to be solved: Design of connections and choice of cable types

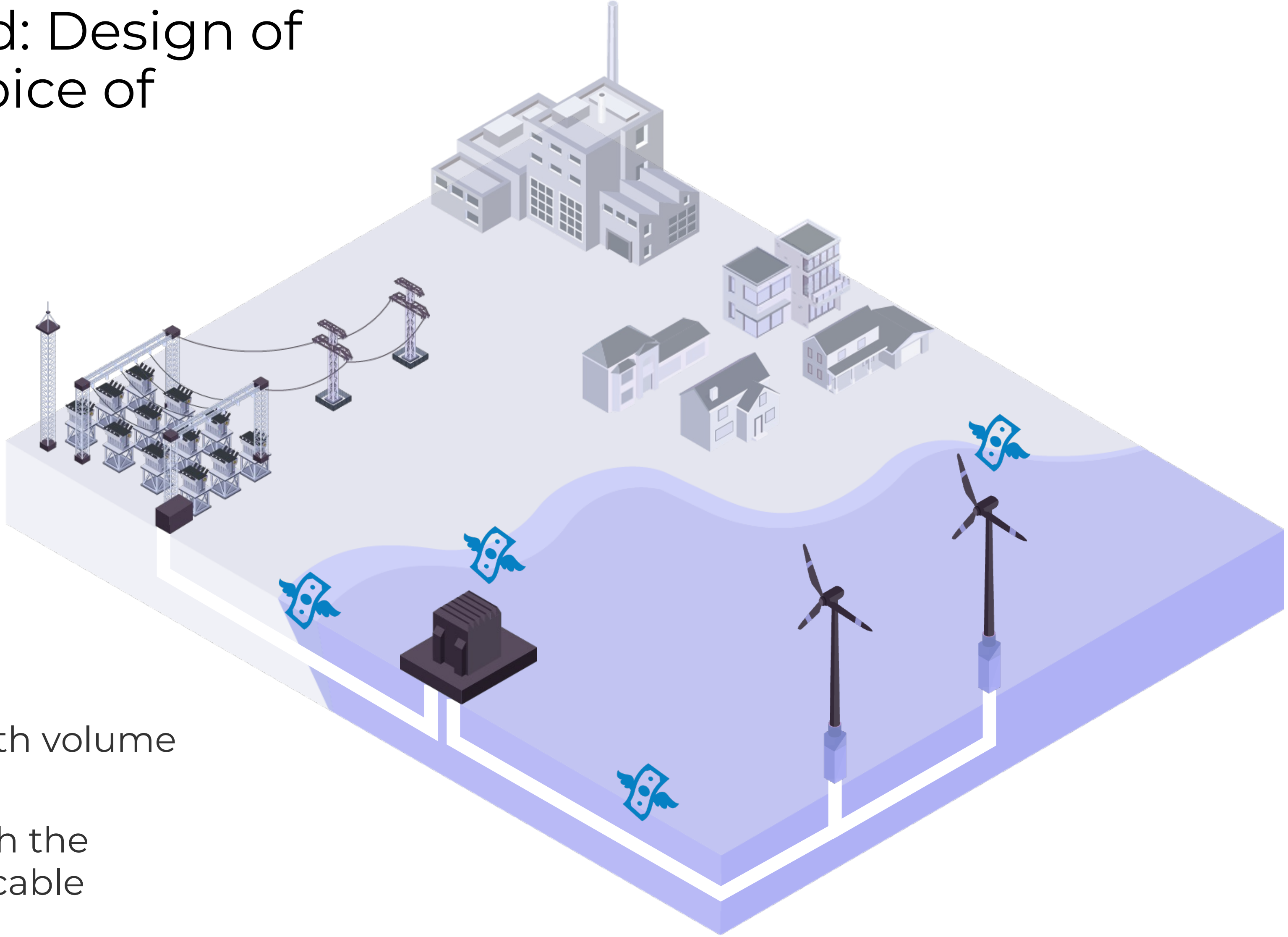
Decisions



2. Establishing the optimal connections between turbines and select the type of cable for each connection

Problem to be solved: Design of connections and choice of cable types

Objectives



Minimizing total construction cost and electrical losses

- CAPEX: Installation costs, with volume discounts.
- OPEX: Losses associated with the transport of energy in each cable

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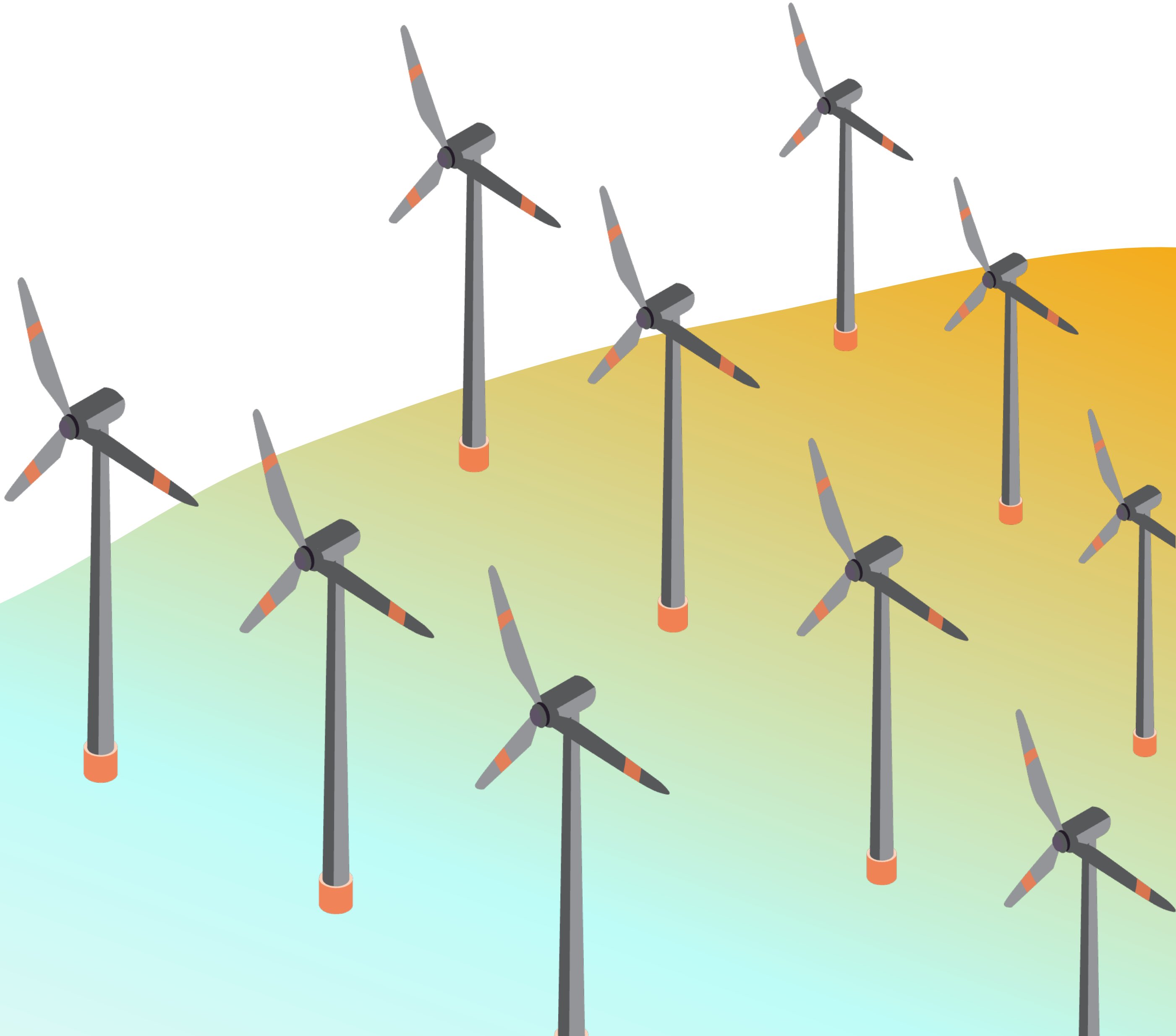
Business impact

- Compared to the previous solution (which already used an optimization algorithm):
    - The CAPEX for the installation of the wind farms is reduced by 0,5%-1,5%
    - Reducing electrical losses by 10%-18,5% is achieved
- The design of the wind farm's the wind farm connections in 100% of the cases analyzed
- The algorithm is allowed to be left free to ideally position the substations
- The proposed algorithms are robust to the different characteristics and particularities of the parks
- Use of Gurobi to solve the problem. It takes advantage of the callback functionality to dynamically introduce constraints into the problem only when they are needed

Predictive Maintenance of Wind Turbines

Advanced Analytics Projects



Implementation process

Use Case

The aim of the project is to maximize plant availability by optimizing maintenance planning.

Plant / turbine condition

Maintenance strategies

01. RUL Estimation

Predictive Model

The predictive model will focus on predicting the failure risk curve for each of the components.

Paramathematic models → Cox Models → Survival Forest / NN

Different failure prediction methods exist, in order to optimize the timing of maintenance, survival models are used which ensure monotonically increasing risk curves.

02. Maintenance Optimization

Optimization Model

Once the RUL has been modelled with sufficient accuracy, we apply a mathematical optimization model based on MILP to determine the optimal time to carry out each maintenance, with the aim of maximizing the generation of the fleet at the lowest possible maintenance cost.

Mathematical optimization using MILP

These algorithms make it possible to find the optimal point that maximizes generation taking into account the risk of failure and downtime costs, considering a global view of the systems and the fleet.

Maintenance optimization

Considerations

- The model selects the optimal maintenance day for each component, combining the risk of breakage with the expected generation according to the wind profile.
- The model allows to include preventive or imposed maintenance, taking them into account and adapting predictive maintenance accordingly when considered.
- The model allows to establish different working capacities depending on the day.
- This model has been designed on a daily basis but can be adapted to an hourly approach or less.
- Tests carried out with Gurobi allow problems of up to several million binary variables to be solved in a few minutes.

$$\max\left(\sum_{t,d} Generacion_{td} - \sum_{t,d} COSTEREP_{id} * x_{id}\right)$$

st:

$$\sum Generacion_{td} \le GENESPERADA_{td} * (1\text{-}\min(1, \textstyle\sum_{i\,|\,i \in T} x_{id}) \quad \forall t, d$$

$$\sum Generacion_{td} \le GENESPERADA_{td} * (1\text{-} \textstyle\sum_{i\,|\,i \in T} PROBROT_{i,d} * (1 - y_{id})) \quad \forall t, d$$

$$y_{id'} = \sum_{d\,|\,d>d'} x_{id} \quad \forall i, d'$$

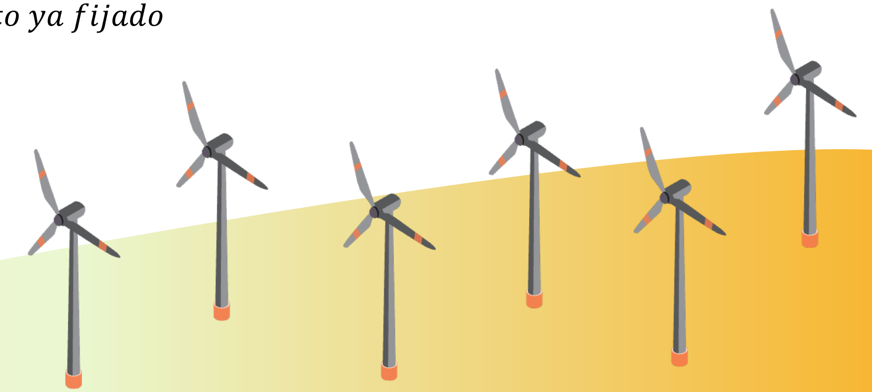
$$\sum_{d} x_{id} \le 1 \quad \forall i$$

$$\sum_{i} x_{id} \le CAPACIDAD_{id} \quad \forall d$$

$$\textstyle\sum_t Generacion_{td} \ge \text{PORCENTAJEMINIMO} * \textstyle\sum_{td} GENERACIÓNESPERADA_{td}) \quad \forall d$$

$$x_{id} = 1 \quad \forall i, d \,|\, mantenimiento\ ya\ fijado$$

$$\sum_{i} x_{id} \ge N \quad \forall d$$



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Insurance

MAPFRE
REALE SEGUROS
GENERALI
asisa
FREMAP
help flash
AXA
multiasistencia

Banking and finances

bankinter
CaixaBank
Santander
axesor
Servihabitat
Edenred
Diners Club INTERNATIONAL

Telco

orange
hits MOBILE
MÁSMÓVIL

Energy

IBERDROLA
CEPSA
REPSOL
Naturgy
RED ELÉCTRICA DE ESPAÑA
VELA ENERGY
imagina energía
capital energy
OW OCEAN WINDS

Logistics and Transportation

JCARRION
IBERIA
Metro
TMB
SGEL
TRANSFESA
Coca-Cola ANDINA

Manufacturing

adif
AIRBUS
PSA GROUPE
BA
HIPRA La Referencia en Prevención para Salud Animal

Services

SERVIZO GALEGO de SAÚDE
PROSEGUR
Global Knowledge
CLÍNIC BARCELONA Hospital Universitari
Parques Reunidos
CEU
GEOQ
AENOR Confía
eldiario.es
Coforge
atsistemas
everis an NTT DATA Company
IBM
TELEFÓNICA TECH

Retail

INDITEX
Sprinter
RGIS
DOUGLAS
Carrefour
nextail
zooplus
DIA

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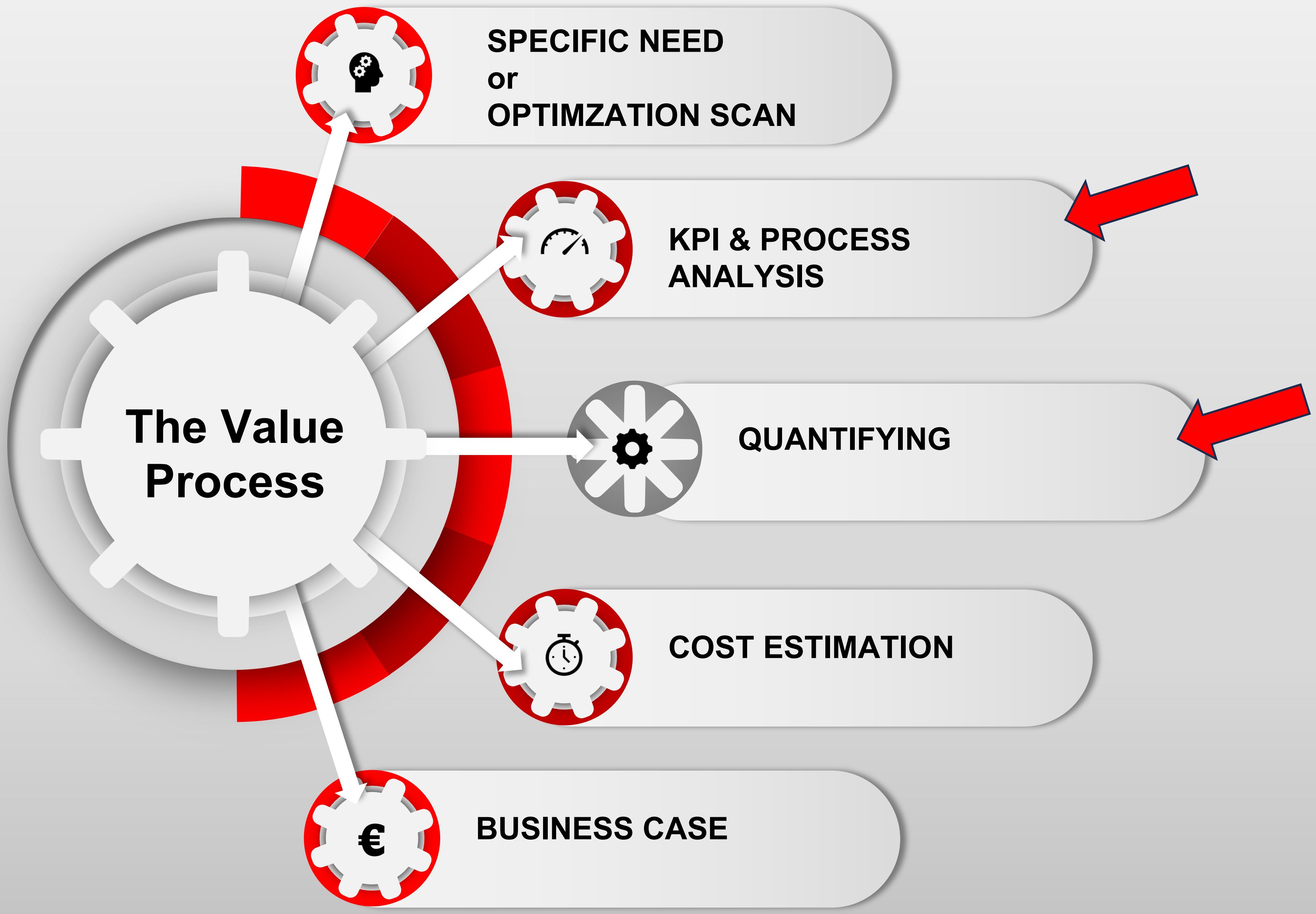
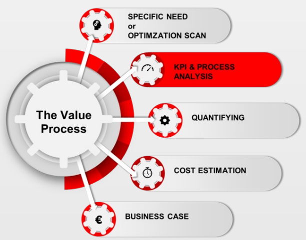
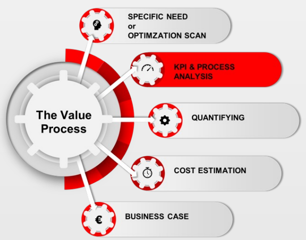

The Value Process
SPECIFIC NEED
or
OPTIMZATION SCAN
KPI & PROCESS ANALYSIS
QUANTIFYING
COST ESTIMATION
BUSINESS CASE



Increase Profitability

- OTIF
- Productivity
- Inventory levels
- Customer Satisfaction
- Lead times
- Employee Satisfaction

- Daily Production
- Resolution Times
- Schedule Adherence
- Productivity per employee
- Goods shipped
- Turn around times achieved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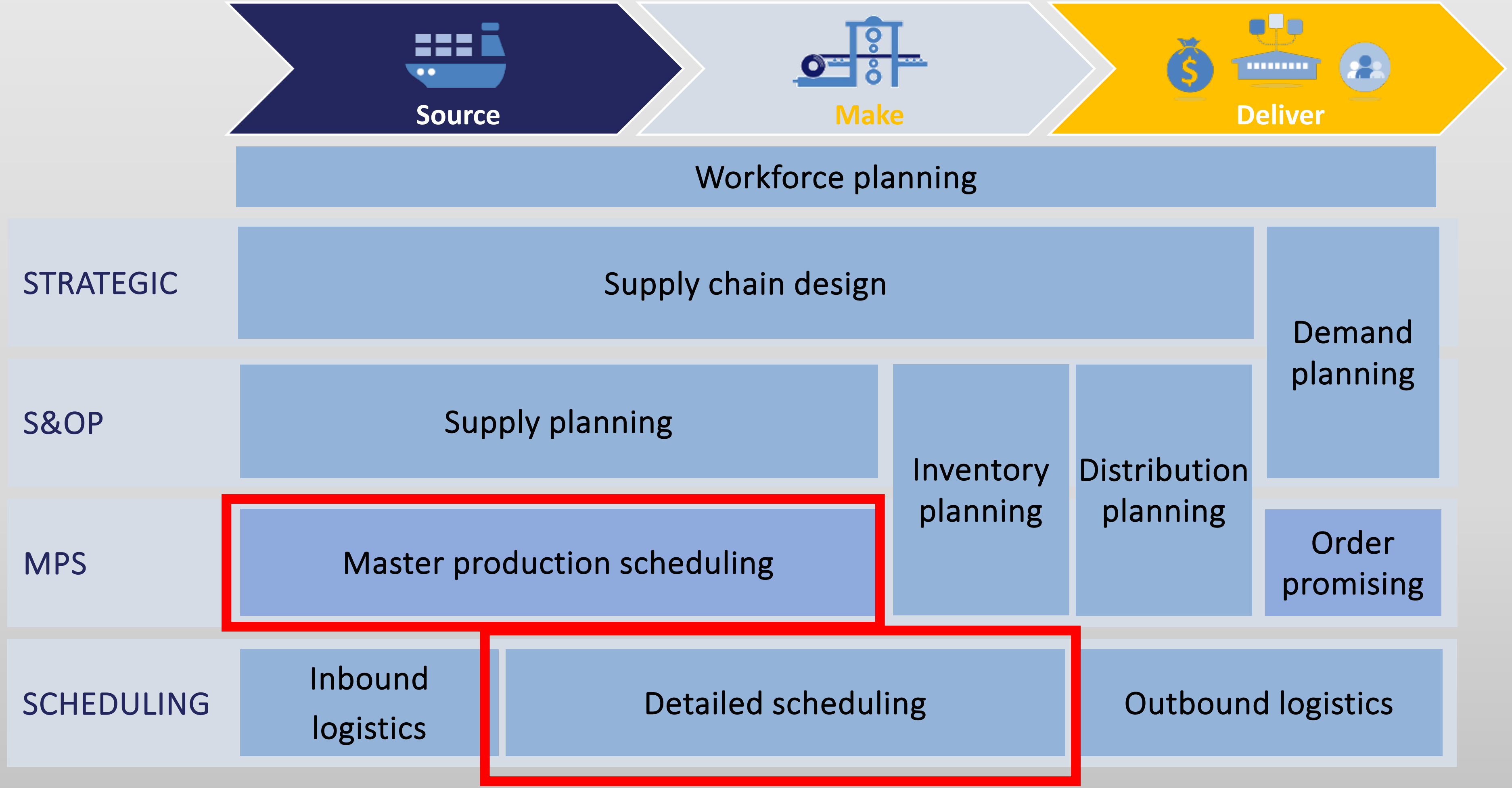
Source
Make
Deliver
Workforce planning
STRATEGIC
Supply chain design
Demand planning
S&OP
Supply planning
Inventory planning
Distribution planning
MPS
Master production scheduling
Order promising
SCHEDULING
Inbound logistics
Detailed scheduling
Outbound logistics

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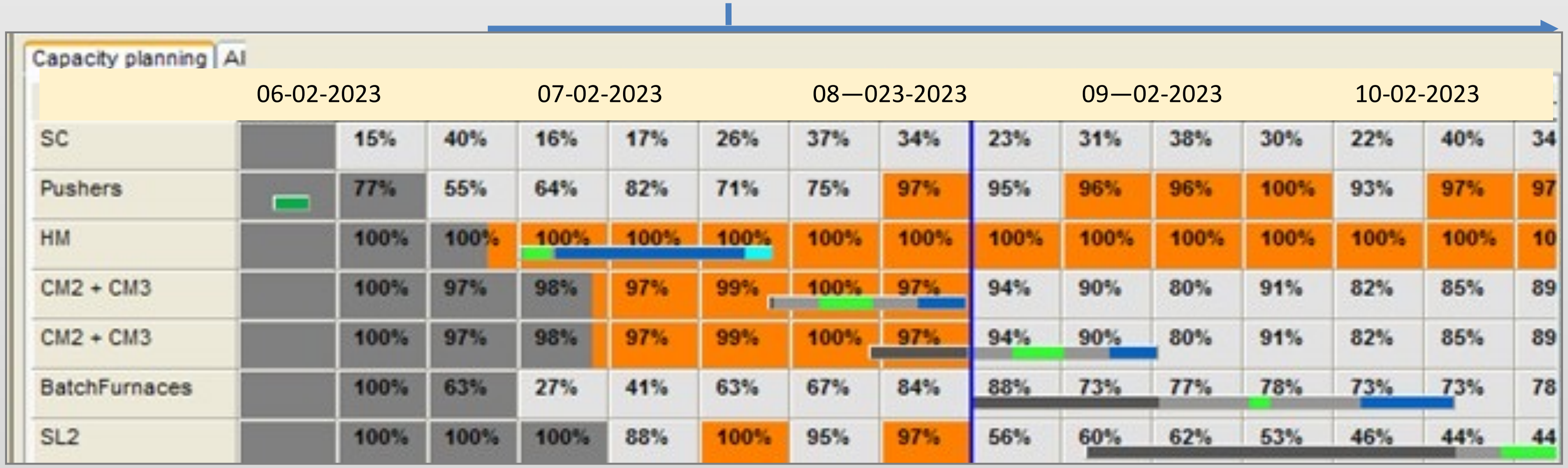
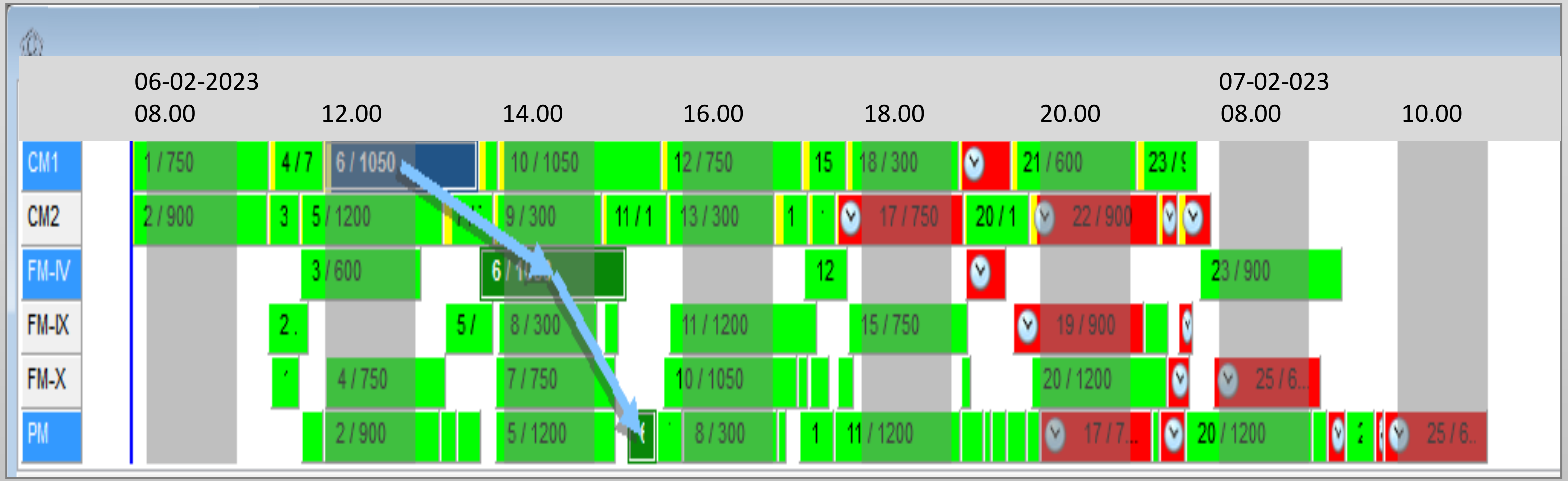


		06-02-2023		07-02-2023			08—023-2023		09—02-2023			10-02-2023			
SC		15%	40%	16%	17%	26%	37%	34%	23%	31%	38%	30%	22%	40%	34
Pushers		77%	55%	64%	82%	71%	75%	97%	95%	96%	96%	100%	93%	97%	97
HM		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	10
CM2 + CM3		100%	97%	98%	97%	99%	100%	97%	94%	90%	80%	91%	82%	85%	89
CM2 + CM3		100%	97%	98%	97%	99%	100%	97%	94%	90%	80%	91%	82%	85%	89
BatchFurnaces		100%	63%	27%	41%	63%	67%	84%	88%	73%	77%	78%	73%	73%	78
SL2		100%	100%	100%	88%	100%	95%	97%	56%	60%	62%	53%	46%	44%	44



Supply chain balancing

Just-In-Time (JIT) strategy to maintain **flexibility**

Sequencing

As-Soon-As-Possible (ASAP) strategy to maintain **productivity**

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01 Benchmarking

Compare with industry standards or experience from other projects

02 Data Driven

Apply ML on historic data to detect performance variances

03 Qualitative

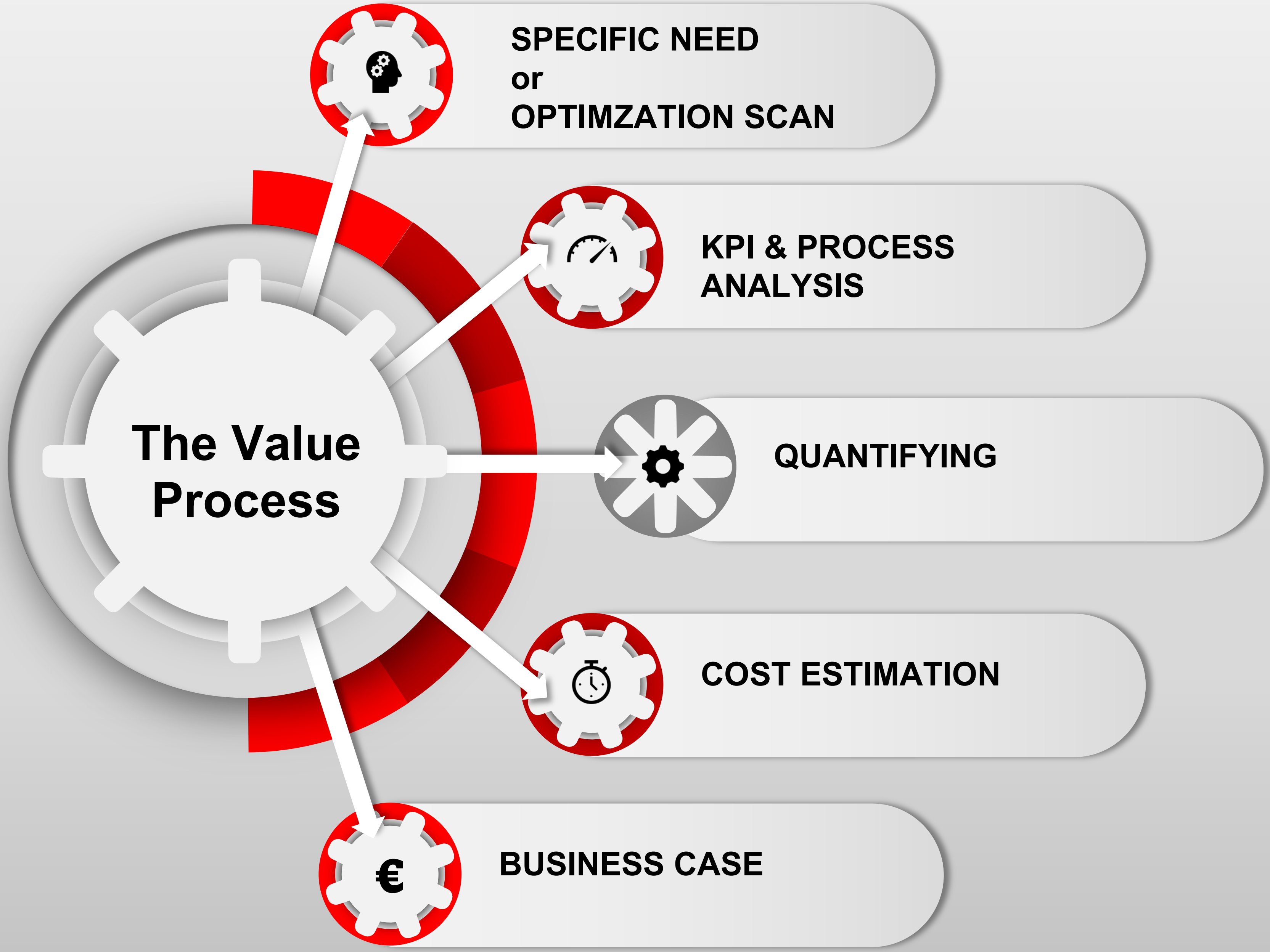
Analyze historic plannings and try to improve

04 Simulation

Build simulation model and manually improve

05 Add Constraints

Build base model and add most relevant constraints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Thank you

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Advanced Analytics for Smart Decisions