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Digitising the energy industry – from data analytics to automatised business processes

XXXIX Heidelberg Physics Graduate Days

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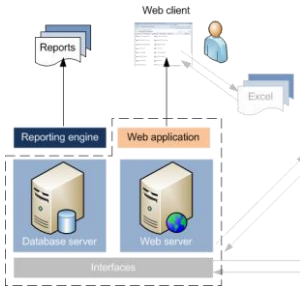
Introduction – digital transformation in the energy industry

The political agenda is driving the transformation of the energy industry. Given the rapid technological evolution, digitisation can answer many challenges

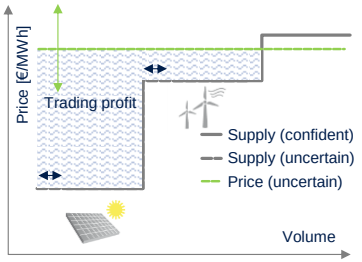
Data availability and acquisition of information

- Development of automatic data interfaces and –platforms with real-time availability for all business areas involved
- Automated evaluation, validation and cleansing of business, market, weather and production data
- Acquisition of useable information from existing wealth of data (e.g. sensor data) based on machine learning



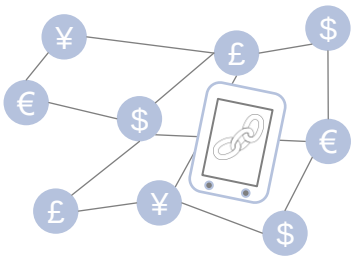
Digitisation of business processes

- Front-to-back process integration e.g. in energy trading based on automated data interfaces
- Elaboration of predictive analytics solutions in particular to optimise the use of physical assets („Predictive Maintenance“)
- Algorithmic support of processes requiring particularly fast decision making, e.g. for energy trading and asset optimisation



Disruptive technologies – proof of concept and operative use

- Representation of business processes using distributed ledger technologies such as Blockchain
- Development of sector and enterprise specific use cases for disruptive technologies
- Proof of concept e.g. for the use of smart contracts based on pilot projects



In recent years, digitisation has become one of the most important drivers of our consulting business in the energy industry.

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Business process automation

Business process modelling and automation

Business processes are an important part of a company's profile

Organisation

- Corporate and risk strategy
- Organisational structure
- Roles and responsibilities
- Infrastructure
- Regulations

→ **Organisational handbook**

Business processes

- Services
- Processes: Activities, Decisions, Events
- Regular checks and operational risk
- Data and information flows
- Interfaces

→ **Business process modelling**

Methods

- Algorithms
- Underlying models as well as functional and technical rules
- Data and data characteristics
- Quality assurance
- Knowledge and Skills

→ **Functional specification**

Process modelling for documentation purposes

- Documentation of functions, roles, responsibilities, …
- Enable knowledge transfer
- Fulfil regulatory requirements
- Modularisation of processes

Process optimisation

- Increase process efficiency
- Increase reusability
- Increase fault tolerance
- Increase reliability

Process digitisation

- Preparation for fully automated business processes
- Definition of process key performance indicators (KPI's) and monitoring of the process performance

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BPMN 2.0 offers a state of the art and future proven modelling language

Business process modelling using BPMN 2.0

1 EPC

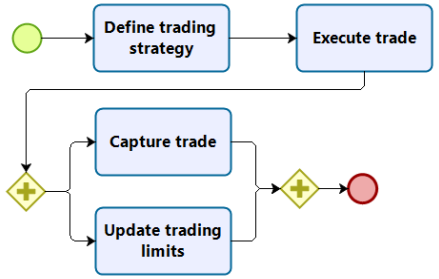
Event-driven process chains

- Developed by August-Wilhelm Scheer et al. since 1992
- Established modelling language based on ARIS approach (supported by various tools)
- ***Purpose***: Business process modelling
- ***Assessment***: Process models are often complex and hard to read

2 BPMN 2.0

Business Process Model and Notation

- Developed in 2002, since 2005 OMG (Object Management Group) standard
- Supported by various tools, including a defined XML-exchange format
- ***Purpose***: Business process modelling and process digitisation
- ***Assessment***: Market standard, intuitive and easily readable



3 UML 2

Unified Modelling Language 2

- Developed in the 90s, since 1997 OMG standard
- Collection of different diagrams with extensive tool support
- ***Purpose***: Modelling of complex IT systems
- ***Assessment***: Market standard, less support for process digitisation

Sources: http://www.omg.org; http://www.bpmn.org

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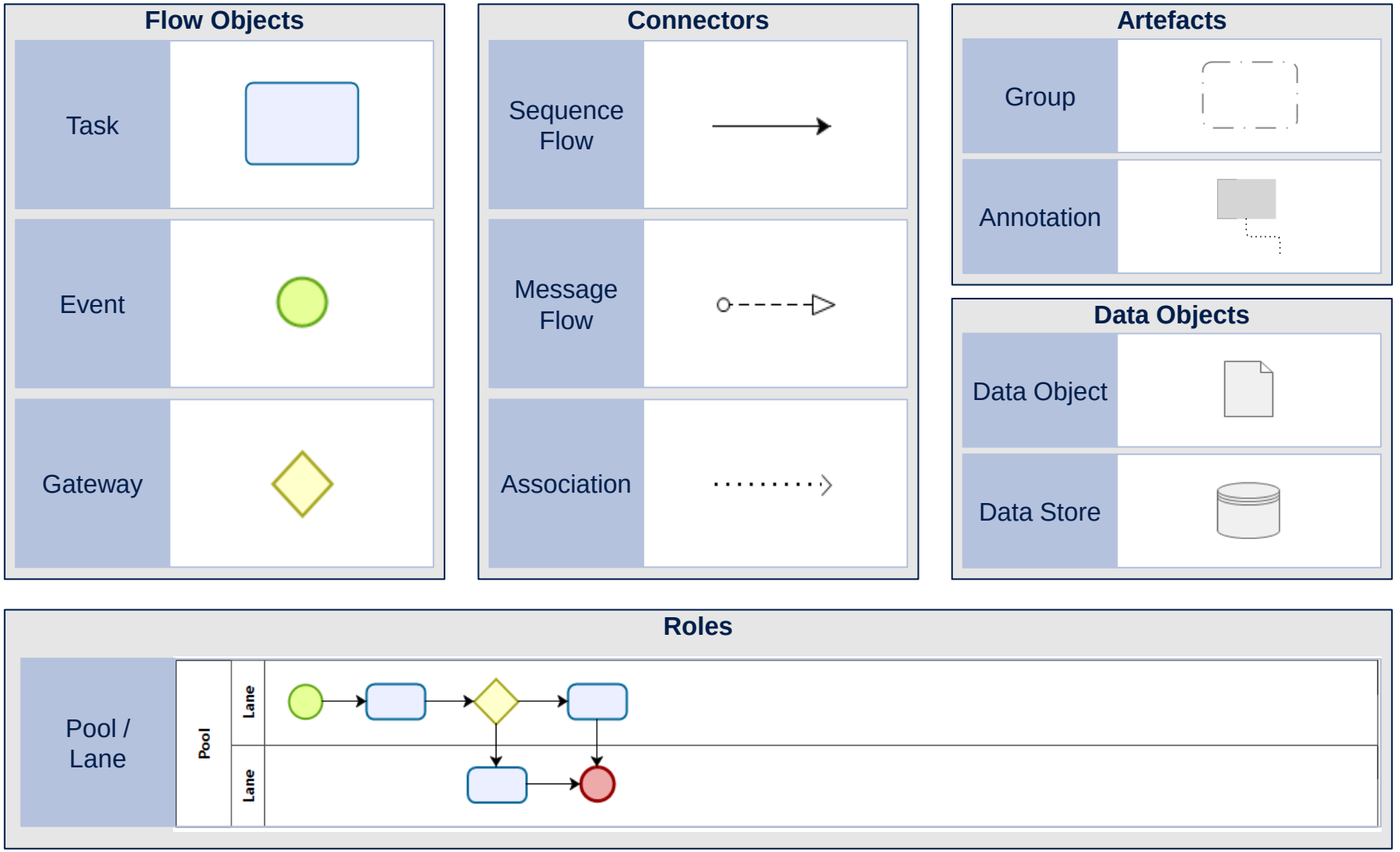
Business processes can be modelled using a few simple components



Constantly analyse and improve the as-is situation using process mining

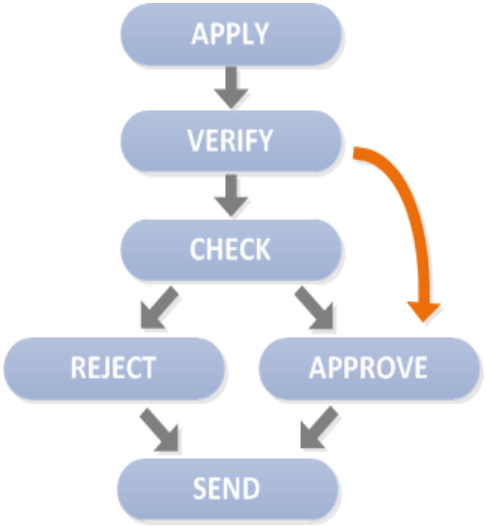
1 Extract required datasets from existing IT infrastructure

- **Digital traces** within the IT-architecture builds the basis to apply process mining techniques
- **Example data** are transaction or event logs from files, databases, etc.

Customer	Activity
1	Apply
2	Check
1	Verify
2	Verify
…	…

2 Apply process mining techniques

- Data mining algorithms are used to **identify key business processes**
- **Exceptions are identified** and made transparent to the user



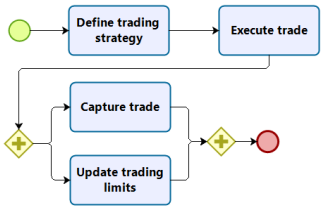
3 Analyse and improve existing processes

- **Discovery:** Gain insights based on the derived process model (in particular analysing exceptions)
- **Conformance checking**: Process models can be compared to the target process (if existing)
- **Enhancement**: Results of the analysis should lead to optimised processes

As-is processes can easily be analysed and optimised using process mining. Various tools are available on the market to support the described steps.

With the help of process mining a company can benefit from digitisation

Why should a company use process mining?



EASY AND FAST TO USE:

» Various tools are available, which are very intuitive to use and highly visual

» First results can be achieved after a couple of days

UNDERSTAND THE AS-IS SITUATION:

» Processes are derived form the “real world” rather than an subjective assessment (e.g. workshops/interviews)

» No knowledge about the underlying processes need to be available. Processes are fully derived from underlying data

IDENTIFY INEFFICENCIES:

» Process specific KPIs to measure process performance and efficiency can be defined and analysed in real time

» Resource needs for process analysis and documentation can be reduced

IMPROVE BUSINESS PROCESSES:

» Identified processes can constantly be improved (e.g. harmonizing process steps, reducing costs)

» Implemented process changes can be instantly analysed, verifying that they have the expected effect

Process mining is a simple and easy-to use process management technique. However, as it is fully data driven, high data quality is a key requirement for the success of process mining.

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Using digitisation to improve companies business processes even further

Process automation and digitisation - Overview

Business process automation aims at technically supporting business processes in order to reduce costs.

In particular the following three fields of application can be distinguished:

(1) Software-supported execution of manual process steps

- » Not fully automatable, manual process steps, are supported by software in the best possible way (e.g. online forms)
- » Increases process efficiency, creating digital footprints and increase the quality of work (e.g. by reducing op-risk)

(2) Full automation of recurring process steps

- » If possible all recurring process steps need to be fully automated using the underlying IT infrastructure
- » Reduces response times, increase process efficiency and takes load from employees

(3) Process monitoring and control

- » Implement possibilities to coordinate and monitor the complete process by an IT-system
- » Real time interaction with executed processes and quality measurement based on predefined KPIs

By enhancing the technical infrastructure underlying a company's key business processes strategic benefits can be obtained.

Blockchain technology for the energy industry

Special features profitably enhances central database technology

Blockchain technology

» Blockchain operates as a **distributed database, including special features,** that contains a continuously growing list of data records, the so called blocks.

» Blockchain technology forms the **basis for a quantity of different applications**, which can also be translated to energy industry

Oracle, etc.

Special Features

- ✓ Decentralization
- ✓ Immutability
- ✓ Digital Assets
- ✓ Smart Contracts

Centralised architectures lacks features like trust and robustness

Centralised architecture

Advantages

» Efficient structure with respect to data storage, messaging and calculation
» Central point of control
» Flexibility to change system
» Proven, mature technology

Disadvantages

» Single point of failure
» Participants need to agree on trustworthy third party
» Processes are done via an intermediary that might add complexity and costs

By storing data across its network, the blockchain eliminates the risks that come with data being held centrally

Distributed architecture

Advantages

» No single point of failure
» Built in trust and consensus
» High degree of transparency
» No trustworthy third party needed

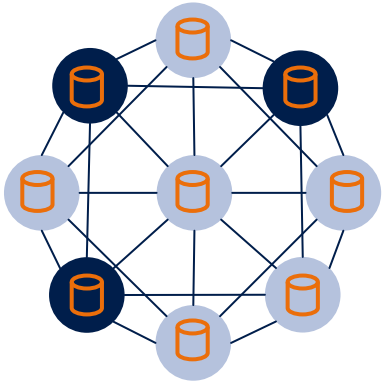
Disadvantages

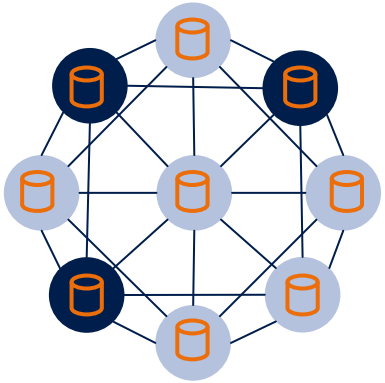
» Inefficient structure with respect to data storage, messaging and calculation
» No central point of control and therefore less flexible
» Still pretty immature technology

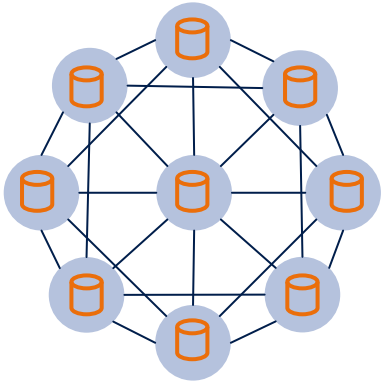
Distributed databases need a mechanism to agree on common view

Decentralization

Each full node holds a version of the database. → **Nodes need to agree on common view.** → **A consensus mechanism will align all nodes.**







Nodes check the validity of the transactions and agree on common view with other nodes.

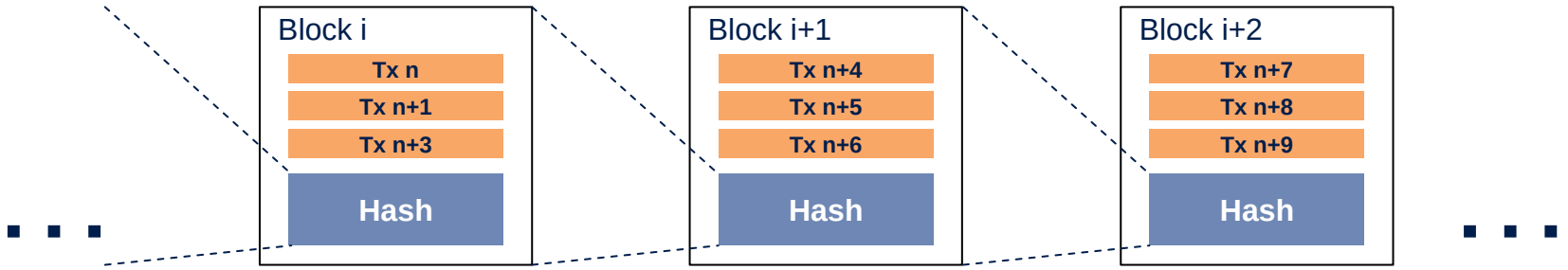
Blockchains are immutable and cannot be tempered with

Immutability of blockchain technology

(1) Transactions can be added

(2) Transactions cannot be removed or unwind

Transactions are saved block wise and single blocks are connected by nested cryptographic hashes.



- A hash code is a “fingerprint” of the previous block
- For a new block, a hash code of the previous block has to be generated
- If there are changes to either the hash code or the block, they are not consistent anymore

Transactions can not be easily manipulated or reversed.

Transactions are bundled in blocks that are connected by cryptographic hashes and are hence immutable.

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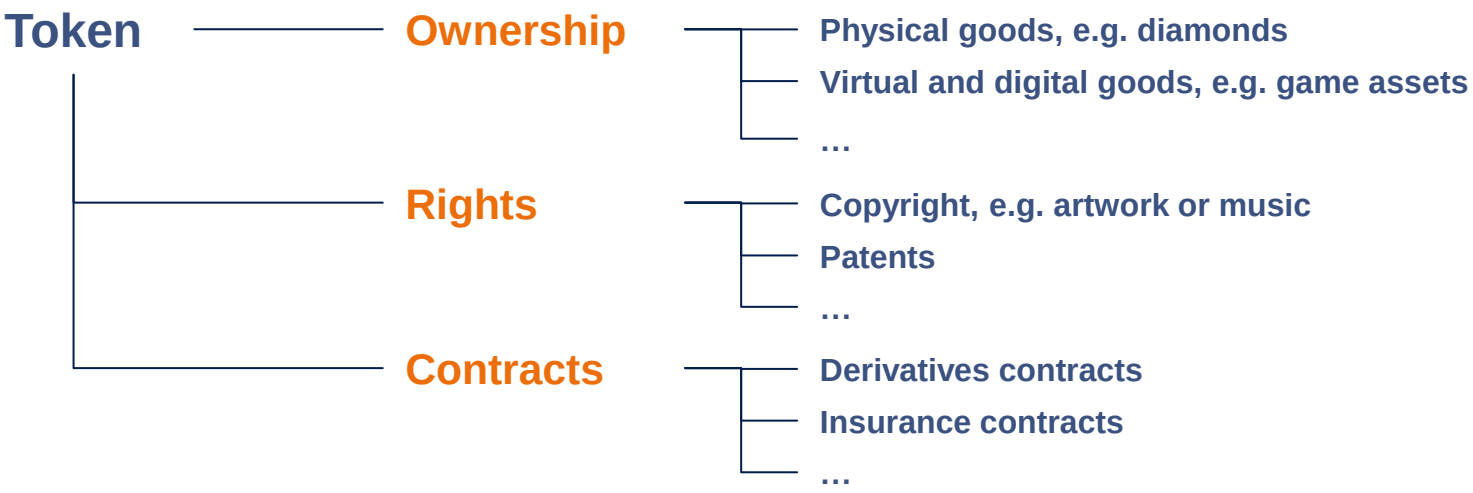
Blockchains can be used to represent digital assets

Types of tokens within a blockchain

(1) “intrinsic” or “native” or “built-in” tokens of blockchains (e.g. Bitcoins)

(2) “asset-backed” tokens issued by a party onto a blockchain for later redemption (see below)

Tokens are used to represent ownership of assets, legal rights or contracts on the blockchain.



Block chain technology solves the problem of digital goods, which usually can be copied and distributed indefinitely (e.g. double spending).

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Smart Contracts offers possibilities to enhance blockchains to allow for easy to implement distributed applications

Smart Contracts are neither smart nor are they contracts …

…instead they are simply computer scripts (dApps), that

- run deterministically,
- provide verifiable execution,
- run autonomously,
- are embedded in a network and
- can change the state of the network.

ETHEREUM **(Example)**

- Provides developers with the tools to build decentralised application
- There is no need to build the underlying blockchain infrastructure
- Ethereum offers the Ethereum Virtual Machine (EVM) which is a Turing complete software that runs on the Ethereum network

Beside the usage of blockchain technology for cryptocurrencies, smart contracts offers an easy access to millions of potential applications of the underlying technology.

Automation of business decisions

An algorithmic approach for marketing of power from renewable energy sources

Direct marketing of power from Renewable Energy Sources (RES) is incentivised by the German “Erneuerbare-Energien-Gesetz” (EEG)

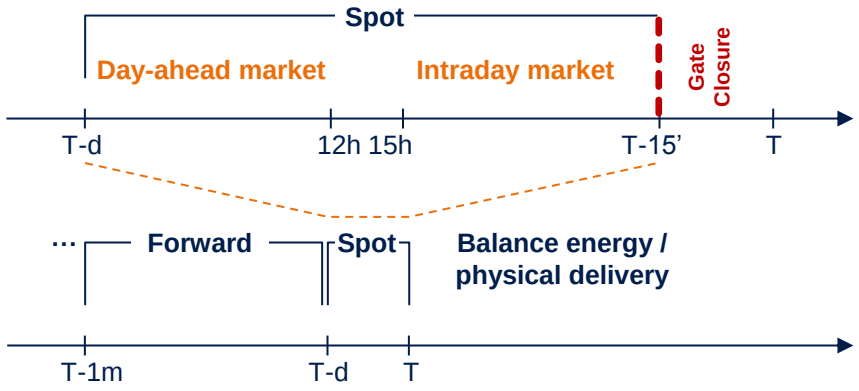
Background

Promotion of RES in Germany

- 2000: *Erneuerbare-Energien-Gesetz* (EEG)
- 2012: EEG amendment (potential *Direktvermarktung**)
- 2014: EEG amendment (mandatory *Direktvermarktung*)

Typical trading firm engaged in direct marketing

- Trading based on market premium model
- Trading on spot, forward or balancing markets



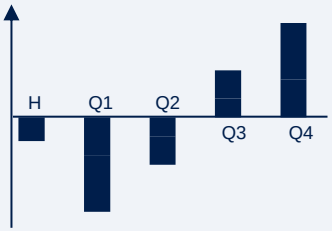
Key challenges

Trading positions

- Uncertain renewable feed-in
- Forecast quality determines confidence of trading positions
- Correlated positions with other renewable traders
- Positions in balance energy can be optimised

Complexities in trading operations

- Parallel monitoring of different order books
- Separation of prop trading and portfolio management
- Positions can be traded in
  - ¼-hourly contracts (Q1, Q2, Q3, Q4)
  - Hourly contracts (H)



➔ **High automation** and optimal **integration in existing** IT-infrastructure required

RES trading poses major challenges as it is based on uncertain trading positions and a high-dimensional set of trading contracts and order books.

* “Direct Marketing”

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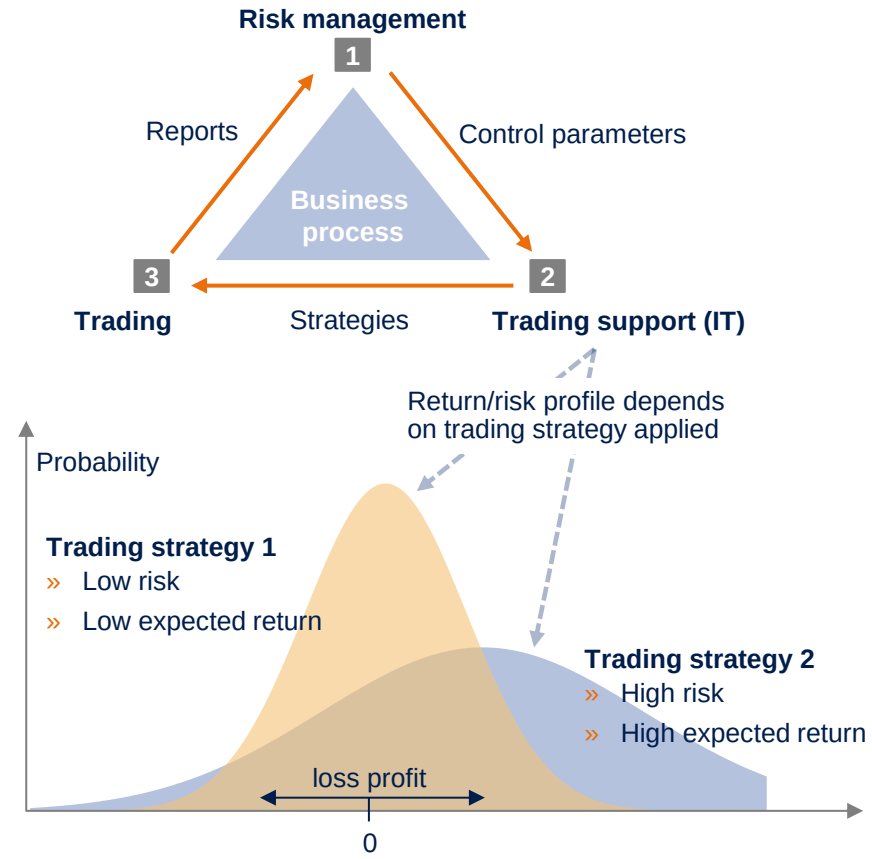
Optimal support of RES trading activities has to be in line with existing business strategies and processes

Basic principle



Requirements

IT-based trading support should ensure

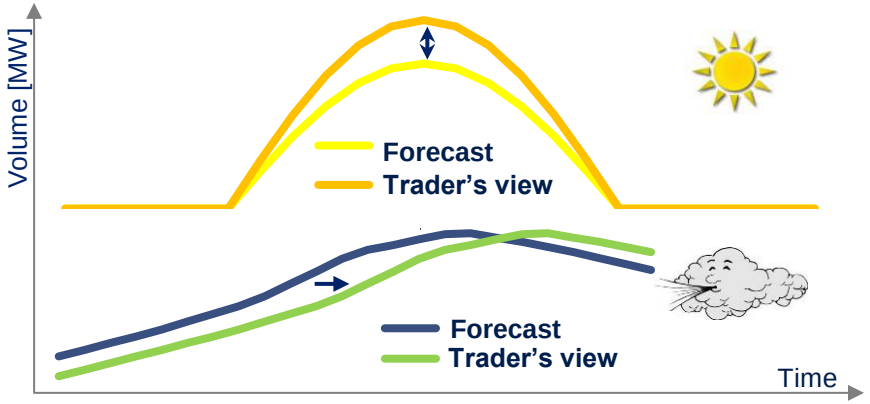
- minimisation of process runtime and complexity
- increase of transparency
- ability for intuitive control of trading activities

Trader

- Individual market view
- Allocation on hourly trading
- Timing and type of order

(Risk) management

- Consistent risk mitigation
- Risk limits
- Position limits



An IT-based support for RES trading has to take into account both the trader's market view and the risk/return profile targeted on company level.

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Operational use of the trading model requires a functional and efficient IT-implementation

Bespoke software design

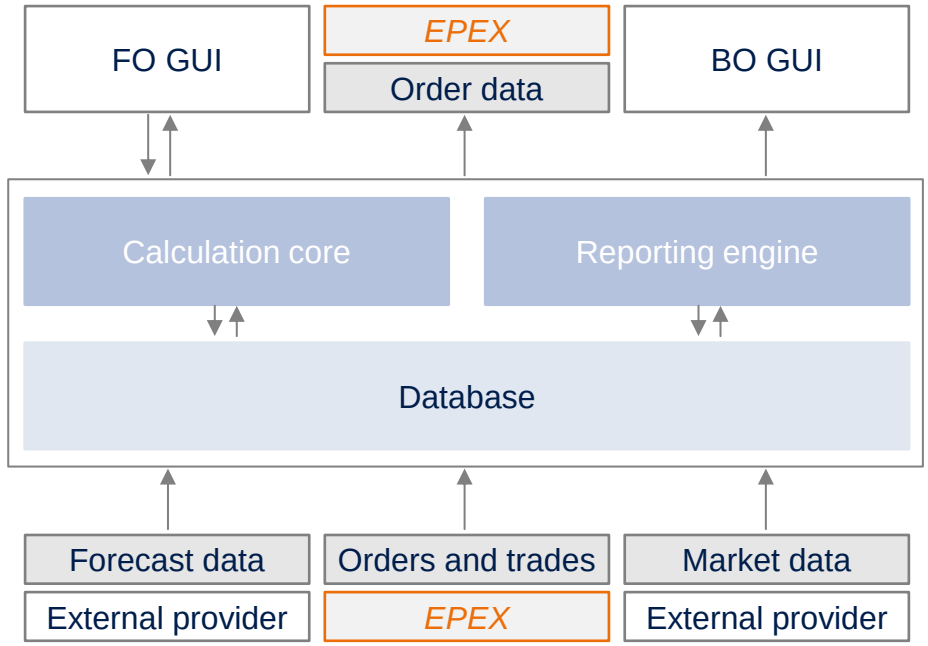
Business perspective

- Design of system tools (GUI, reports) to support business processes in the best possible way
- Flexible response to changing client needs
- Leverage of system database as a valuable, multi-purpose resource (further reporting, analyses, etc.)

IT perspective

- Integration into existing IT infrastructure
- Flexible interfacing of existing resources (databases)
- Individual options for performance optimisation
- No dependence on external system vendor
- Extendable solution through open source code

Solution architecture



Our solution is designed to cover exactly our clients' business requirements and to efficiently integrate in the existing IT framework.

The efficient implementation of complex software requires a flexible and transparent software development process

AGILE MANIFESTO (agilemanifesto.org)

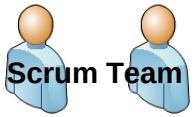
- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

Basic ideas of Scrum

- Scrum defines **a framework for a flexible and transparent software development** process
- **Problem**: Complex software systems cannot be planned with sufficient details upfront
- **Solution**: Requirements are not fixed at the beginning of the development process, but can be adjusted in due course
- Scrum defines software development as an **iterative process** (iteration = sprint ~ 2-4 weeks), each containing planning, implementation and review

Roles of Scrum

- Defines the requirements for the targeted software (product backlog)
- Sets priorities to these requirements
- Responsible for the implementation of the “right” software



- Generates effort estimates for the elements of the product backlog
- Selects requirements to be implemented within the next sprint
- Implementation (self organised)

- Supports Scrum teams and facilitates efficiency
- Ensure Scrum discipline

Scrum offers the possibility to efficiently react of changing requirements within software development.

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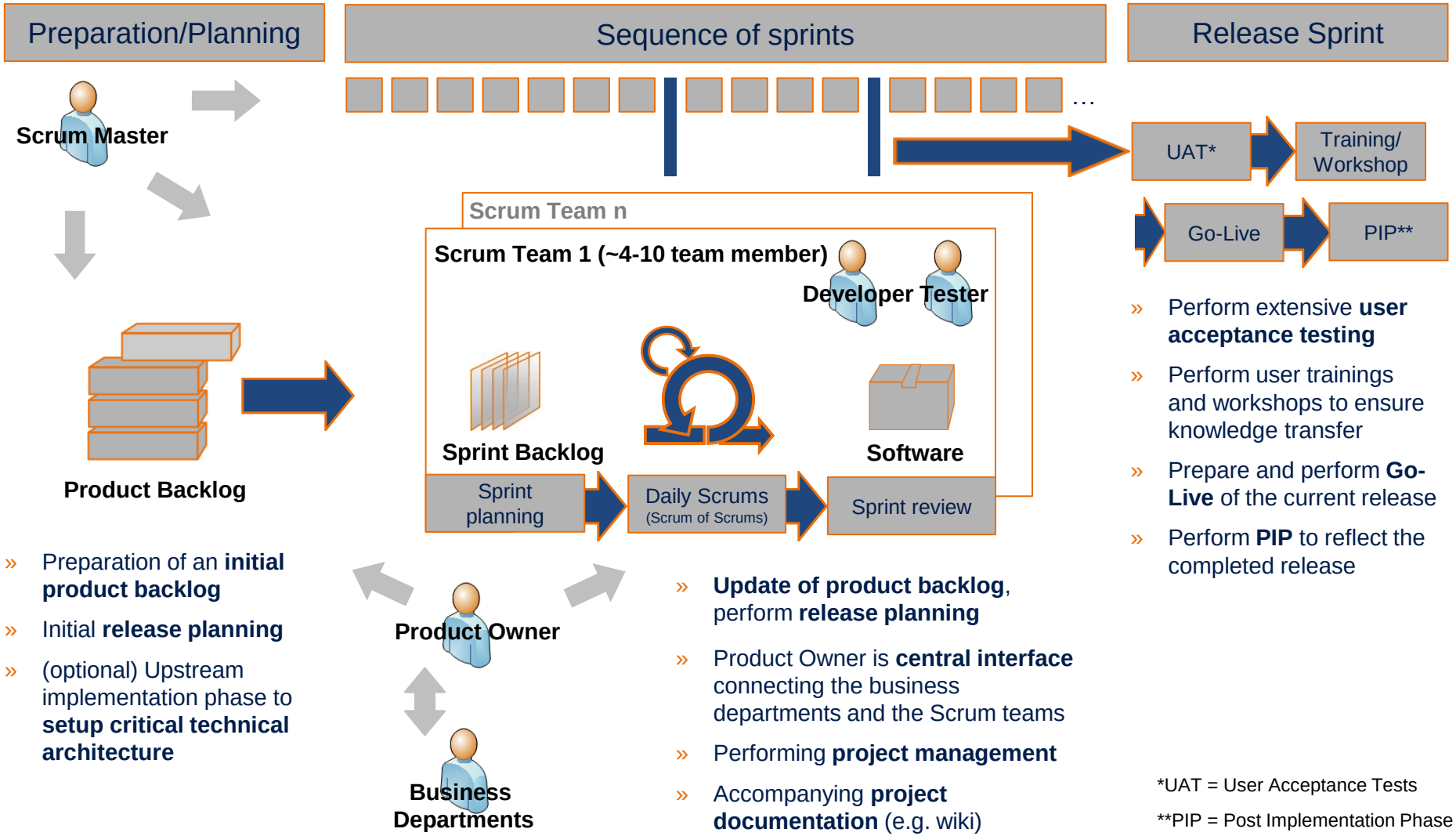
Scrum uses repeating cycles of planning, implementation and review to reduce complexity in software development



- Preparation of an **initial product backlog**
- Initial **release planning**
- (optional) Upstream implementation phase to **setup critical technical architecture**

- **Update of product backlog**, perform **release planning**
- Product Owner is **central interface** connecting the business departments and the Scrum teams
- Performing **project management**
- Accompanying **project documentation** (e.g. wiki)

- Perform extensive **user acceptance testing**
- Perform user trainings and workshops to ensure knowledge transfer
- Prepare and perform **Go-Live** of the current release
- Perform **PIP** to reflect the completed release

*UAT = User Acceptance Tests

**PIP = Post Implementation Phase

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Integrated energy – combined heat and power generation capacities (CHP)

Starting point, challenges, goals and approach

Starting point

Forecast and optimization of the plant operations

- Operations
  - Dispatch based on long term heat demand forecast
  - Short term adaption to heat demand and power price
- Trading / Marketing
  - Trading of all plants as a single portfolio
  - Marketing of district heating via long term contracts
  - Trading of power via short term markets
- Hedging of market risks
  - Physical hedging (sale of plant schedules to a service provider)

CHPs (examples)

- Coal fired plant
- Waste fired plant

Challenges, goals, approach

Develop a concept for an enhanced asset management approach

- Gap analysis for the existing plant marketing
- Estimation of the potential of (half-automated) intraday trading
- Prototypical implementation of an alternative plant marketing at the futures market

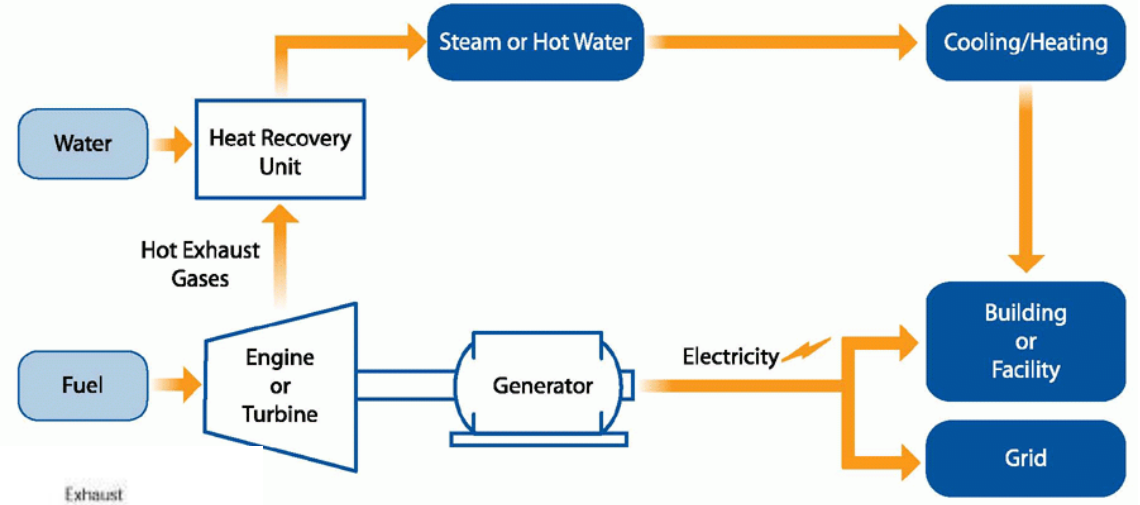
Choice of models and their calibrations for the simulation of power price and heat demand

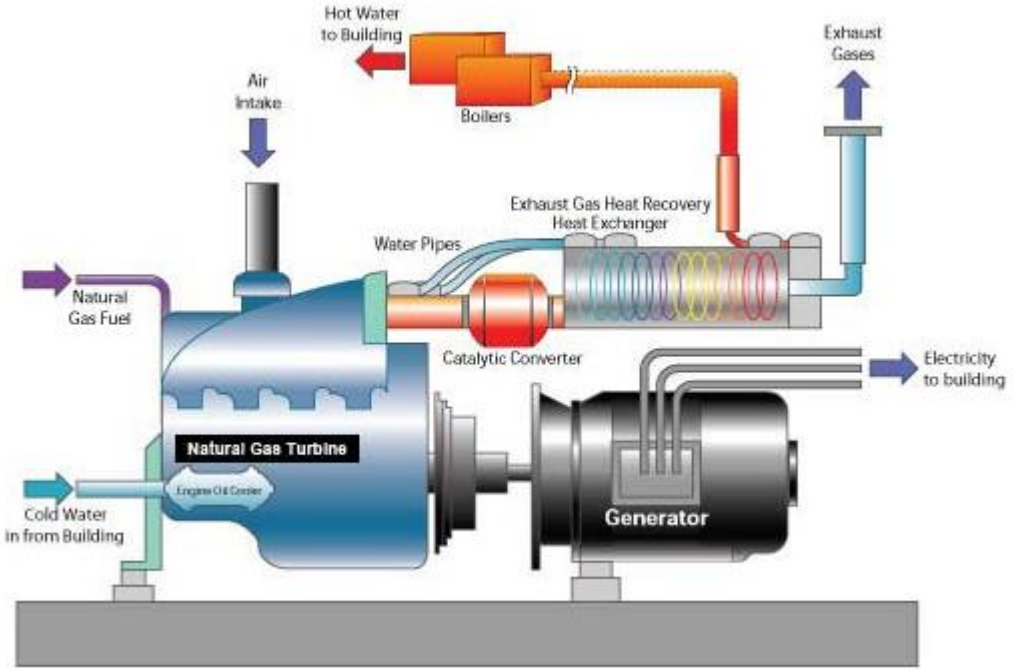
Modelling and optimization of the plants at our client

Evaluation of different hedging strategies

Combined heat and power generation capacities

- Cogeneration or combined heat and power is the use of a heat engine or power station to generate electricity and useful heat at the same time
- By capturing the excess heat, CHP uses heat that would be wasted in a conventional power plant, potentially reaching an efficiency of up to 80%
- The balance between heat and power generation can be controlled (to a certain degree)
- Subsidy for CHPs in Germany regulated in KWKG





- Energy conversion efficiency (η) is the ratio between the useful output of an energy conversion machine and the input, in energy terms. In practise this is not straightforwardly determined.

Technology	Efficiency [%]
Atomic	33
Steam turbine (thermal only)	25–50
Steam turbine (combined cycle)	50–60
Solar	5–27 (40 max)
Water	80–90
Wind	50 (max)
CHP	60–80

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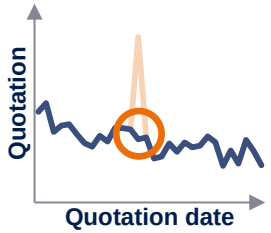
Modelling, evaluation and comparison of alternative trading strategies

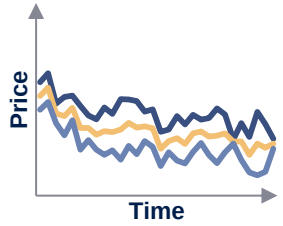


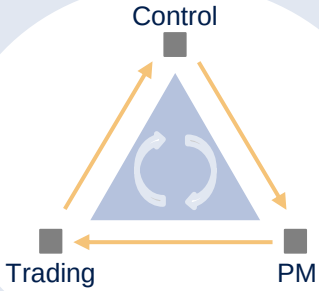
(Market) data

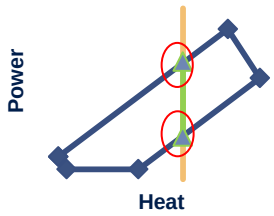
- Historical heat demand and power prices, HPFC* und heat demand forecast
- Model for HPFC

Process modelling

- Modelling of the heat demand and power price
- Calibration of the models based on the HPFC, heat demand forecast and historic data





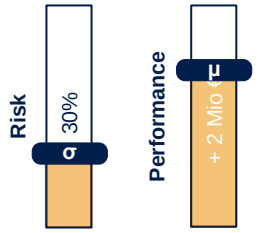


Plant optimization

- Heat demand oriented operation
- Calculation of the optimal mode of operation depending on the heat demand and power price

Trading and hedging

- Static delta hedging
- Dynamic delta hedging
- Tranched hedging
- (Half-)automated intraday trading



*HPFC = Hourly Price Forward Curve

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