

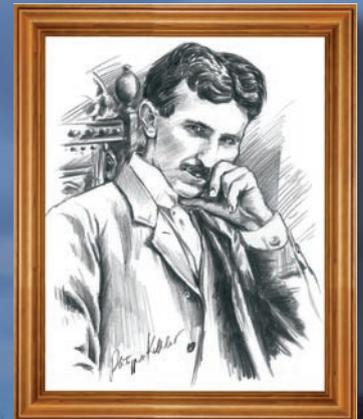
BelVis ResOpt

ENERGY MARKET SYSTEM

Efficient Resource Management.



SALES | PROCUREMENT & TRADE | GENERATION | INDUSTRY



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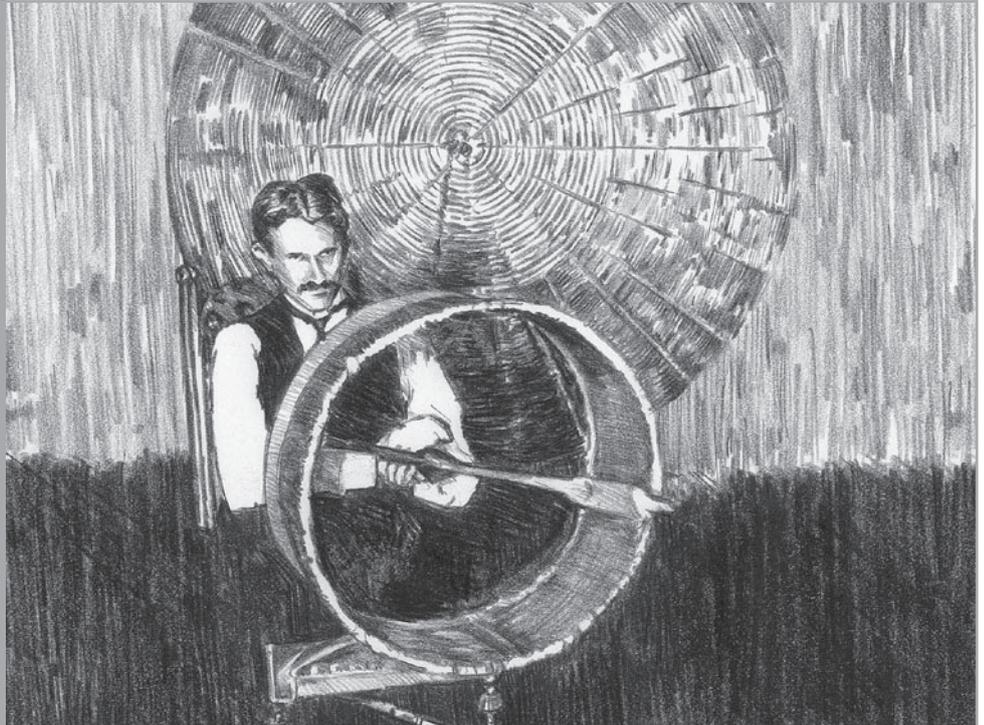
Because electrical energy transmission is far more economical than all other methods we know of today, it will necessarily play an important role in the future.

Nikola Tesla | Electrical inventor and constructing engineer

 **KISTERS**
Pioneering Technologies.

The cradle of the electrical industry.

Nikola Tesla's great dream was to supply the entire world with energy. After having developed the principle for the generation of rotating magnetic fields, he was faced with the task of making the ingenious idea practically useful. After a series of prototypes, Tesla developed the multiphase induction motor: stator coils affixed to the casing are fed with two-phase alternating current resulting in a rotating magnetic field. Because the motor did without a commutator and sliding contacts, it was the first not to spark and squeak. Nikola Tesla's alternating current method and his multiphase induction motor were the foundation of the modern electrical industry.



BelVis ResOpt Integrated solutions for resource management optimisation.

Everything is connected, everything is increasing! Consumption of energy resources, pollutants in water, air and soils, pressure to handle global resources economically and responsibly. Decision makers find themselves in a world of complexity, and the grand scheme is less and less apparent, even with complete information on all individual components and their interdependencies. High resolution data, precise forecasts, conversion and distribution processes, market guidelines and legal restrictions must all be "properly" combined in order to reach the best possible decisions on the deployment and quantities of resource streams. Not all roads still lead to Rome, and recognising the right path under the plurality of conditions approaches the limits of what is possible

with human cognition. Today, optimisation software is tasked with finding the best of many possible solutions, and transforms the complexity into clear statements and simple efficiency.

For 25 years, the KISTERS Group has been the senior expert in the field, promoting effective and efficient deployment and achieving sustainable goals through use of information technology for resource management. The highly-integrated BelVis software portfolio employs BelVis ResOpt to quickly and reliably solve optimisation tasks across all planning intervals and for all resource streams. On this basis, overall economic and ecological effects such as rising prices, resource bottlenecks and climate change, as well as their consequences, may be managed over the long term.

BelVis ResOpt is the optimisation software for all participants in the energy market, from the generators and IPPs (Independent Power Producer) to energy supply and public utility companies, right through to energy-intensive industry players. BelVis ResOpt optimally plans out structures, resource streams, portfolios and systems, and plans the management of energy resources in a multi-energy and multi-market environment with the clear goals of

- increasing profit
- reducing costs
- protecting resource streams and
- avoiding emissions.

BelVis ResOpt - The optimisation implant

The goal of entrepreneurial trade is certainly to achieve optimum results from a plurality of resource interactions; however the means of doing so is often a tough code to crack.

Energy sources and sinks, resource streams and transport routes, plants and technical units, procurement and supply contracts, legal and commercial frameworks; an enormous multitude complicated further by short, medium and long term effects operating in deviating directions - the potential for cost saving, increased profit and resource conservation may as well be an uncrackable code when it comes to human biology. A trusted "I, Robot" will become essential to tap the full potential of resource management optimisation.

BelVis ResOpt optimises the entire system environment. By integrating all resource streams, parameters, boundary conditions and planning intervals, it is able to determine optimal plant structures, portfolios, planning processes and contract structures. The result:

- increased operating efficiency
- greater added value from the own system and the portfolio and
- best possible, secure and rapid decisions on plant management, resource and contract planning, as well as planning of trade activities.

BelVis ResOpt ensures the best possible decision even at early stages, such as when examining potential yield on an initial investment. System logic demonstrates the possible savings and profits of a tailored BelVis ResOpt solution as a Return on Investment (ROI) in an upstream analysis phase. This will state profit contributions from the various deployment decision processes. Experience has shown power plant optimisation systems typically have a short ROI. And in the long term, overall economic and ecological effects such as rising prices, resource bottlenecks and climate change may be managed with success.

Model the value. From asset through to multi-commodity optimisation over all planning intervals

Immediately upon introduction of BelVis ResOpt, the system will map the user portfolio with all its assets, together with their relationships and dependencies. Assets are sources, sinks, conversion aggregates or generators and transport paths for different resources types such as gas, power, water, heat, emissions, and much more. The resource portfolio consists of the assets entwined in their respective volatile markets.

The system relies on a comprehensive library of functions, even while processing the first representation. The model which arises is the foundation of the optimisation process, and can be modified at any time through the easy-to-use modelling interface.

The optimisation processes themselves either run automatically under the control of a workflow, or are initiated manually by the user. The powerful PROMETHEUS calculation engine carries out optimisation rapidly using the latest information. The results time series are transferred to the BelVis interface in the form of e.g. graphs, tables and reports.

Speed climbing with top-rope. BelVis ResOpt brings added value to assets and portfolios

On this basis and with the inclusion of all values and restrictions, BelVis ResOpt automatically reaches the best possible decision on the deployment scale of resource streams, on the operation, power and schedule of every power plant and on the structure of the

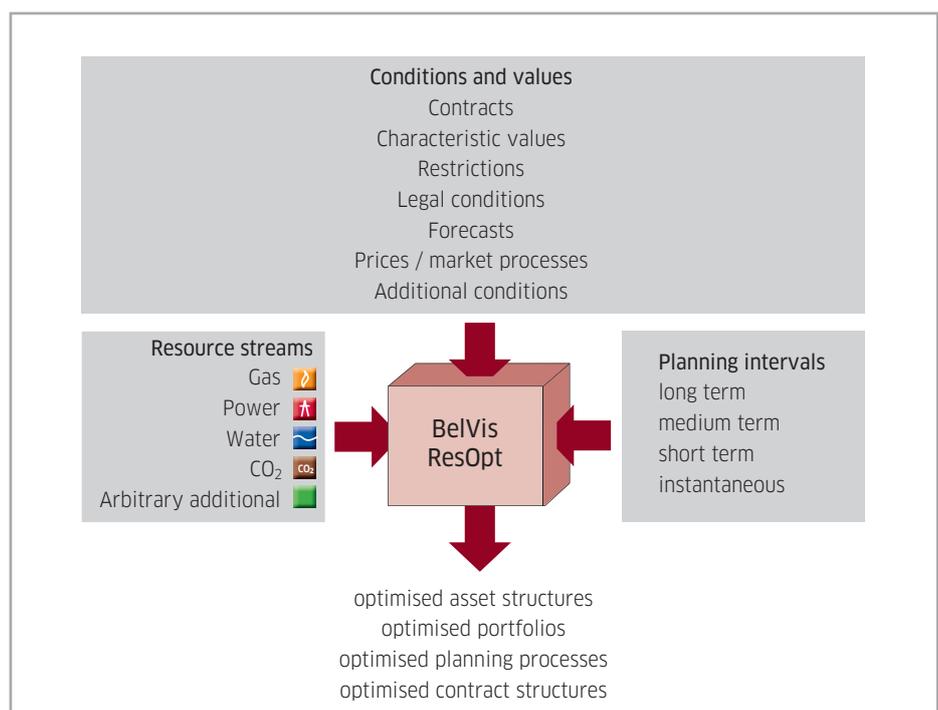


Figure 1: BelVis ResOpt considers the complex interrelations between all factors

generation and distribution network system.
BelVis ResOpt

- supports multi-utility optimisation with multiple clients,
- delivers optimal profit contribution-oriented results under consideration of basic technical conditions,
- considers long, medium and short term planning intervals, including current resource planning, day ahead and intraday
- integrates all sectors: gas, power, heat, water, CO₂ and any other resource streams.

Optimisation takes place across all sectors, under consideration of all relevant

- plant and storage values,
- energy procurement contracts,
- consumption loads,
- CO₂ emissions,
- legal boundary conditions and
- other values and conditions.

From the potential to perform, to action: the primary applications of BelVis ResOpt are

- asset management and asset optimisation: structure, operations and market positioning of power plants or other physical generators, storage, transport systems and consumers are improved.
- Portfolio management and portfolio optimisation: targeted deployment of procurement, marketing and transport contracts leads to good market positioning and improved management of the portfolio. Mechanisms ranging from comprehensive scenario evaluations through to complex scenario trees are used as support.
- Resource and energy management solutions with different characteristics: suitable forecasts and management and optimisation functions support business processes to the greatest extent possible.

- Virtual power plants: Even operators of smaller plants may profitably participate in the minutes reserve market using virtual power plants optimised with a view to profit contribution.

These capabilities may be combined into complex optimisation scenarios to be quickly and reliably solved by BelVis ResOpt. All participants in the liberalised energy market - resource planners, plant operators, traders, energy suppliers, decision makers in energy-intensive industry and many more roles - stand to benefit from comprehensive support of their business.

BelVis ResOpt capitalises on chances provided by a volatile market through targeted asset deployment as well as both upstream and downstream assets, including “dormant” assets such as e.g. storage facilities and switch-off customers. BelVis ResOpt achieves greater added value of the own assets and improved portfolio management by supporting decision making processes in a wide range of scenarios and through automated support of long, medium and short term planning and procurement processes. BelVis ResOpt reaches the highest possible added

value to the portfolio under all technical, commercial and legal boundary conditions by optimally deploying all available assets.

Procurement optimisation makes increased returns a reality for public utility companies and energy suppliers. The application of power plants and procurement contracts to all markets opens the door for generators and IPPs to see increased profits. Energy-intensive industry can minimise its costs through portfolio optimisation.

Automated planning processes over all time ranges

“Time is nature’s way of keeping everything from happening at once.” Consistent optimisation therefore means planning over a long timeframe. For this reason, even rapid decisions with short term consequences can only be made with an eye to long term planning. Effective portfolio and asset management must include all time frames and support corporate planning processes as a whole, all while realising the greatest extent of automation possible. BelVis ResOpt provides decision-making support in the deployment of energy and resource streams in long, medium and short term planning processes,

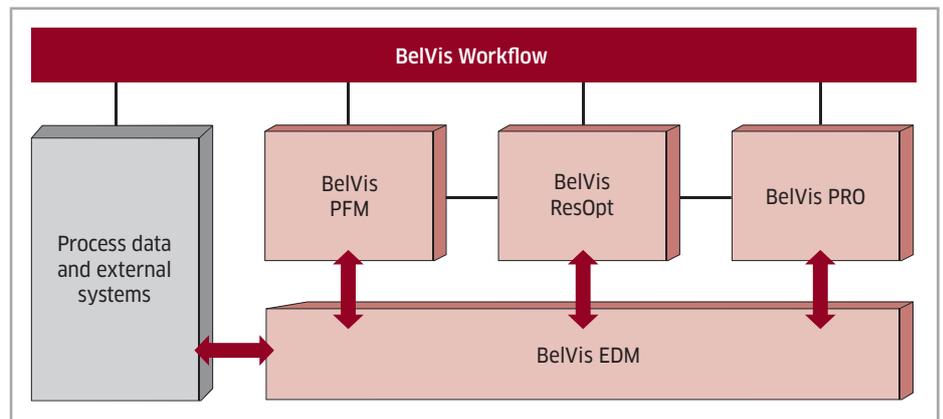


Figure 2: BelVis ResOpt is completely integrated in the BelVis system architecture

right through to intraday planning. In inter-linked optimisation processes, decisions in long term planning scenarios serve in turn as parameters for short term planning processes, for example the distribution of monthly quantities or the maximum reference performance levels (Figure 3). When carrying out planning processes, BelVis ResOpt supports several different offer proposal options and an unlimited number of definable scenarios for the following evaluations.

Technology beyond the horizon

From practice to technical insights, from application samples to the concept. Everyone responsible understands: the system plug-in to the complex reality of the energy market is a necessity, and only a software portfolio offering maximum flexibility, configurability and communication processing capabilities can bring about real utility under conditions of continuous market change.

Architecture for customer solutions

BelVis ResOpt is a component of the BelVis product family, a system of component software which covers the entire spectrum of processes in the energy market. Seen as a single unit, the portfolio can guarantee consistent data structure and smooth communication. Standardised components may be combined as necessary to meet specific customer needs, and additional modules can be added at any time to meet changing requirements. KISTERS functions in the role of finding and configuring your solution from initial contact on, building the most suitable software solution for the customer based on existing tasks and workflows.

Architecture for communication

All BelVis components exchange data using the high-performance BelVis time series management system. Seamless integration in the BelVis system environment and interfaces to

Digital symbiosis! BelVis ResOpt networks the data world into unique reciprocal benefits

external software solutions guarantees that BelVis ResOpt always has access to comprehensive current information, which can be used to prepare schedules over all planning intervals.

BelVis ResOpt draws all current information into the optimisation process, e.g. data sets prepared and checked for plausibility by BelVis EDM (Energy Data Management) and BelVis PFM (Portfolio Management), and forecasts prepared by 20 highly developed methods in BelVis PRO. In turn, the results and guidelines resulting from optimisation in BelVis ResOpt are available to all other BelVis components through time series management. For example, the trading module BelVis PFM POWER can process the optimisation results in portfolio management for optimal positioning on the EEX market and for market communication (e.g. with the EEX). In the same fashion, the trading module BelVis

PFM GAS can handle optimised procurement of complex gas supplies for a gas and steam plant, again based on the BelVis ResOpt results. The BelVis WorkFlow integration component organises the BelVis modules to handle complex tasks as necessary, both internally and externally, and generally ensures smooth operation.

BelVis integration with external systems

Although BelVis ResOpt is entirely integrated into the services of the BelVis product family, it is also completely capable of being deployed in combination with external energy data management systems. The BelVis platform provides native support for established international market formats, including in Germany, the Netherlands, Switzerland, Austria and Italy. BelVis ResOpt integrates its optimisation processes into the respective IT environment and business processes through communication in these formats and their as-

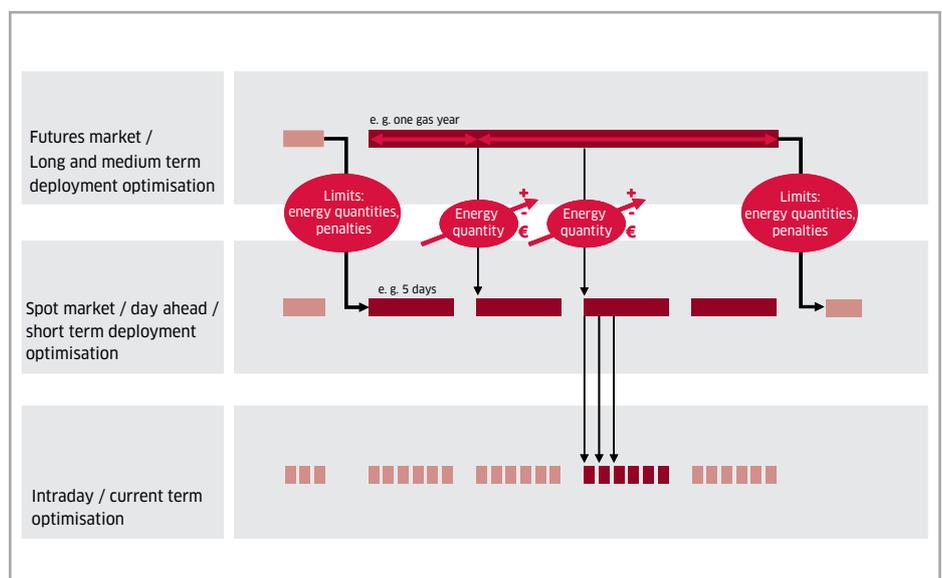


Figure 3: Integrated optimisation over all planning intervals

sociated workflows. By interfacing with trade and risk management systems (e.g. ZaiNet by SunGard), it is also possible to implement high-performance ETRM systems (Energy Trading & Risk Management) with full settlement and portfolio optimisation.

Applied mathematics: optimisation with BelVis ResOpt and PROMETHEUS

BelVis ResOpt can model the highly complex and networked optimisation scenarios found in real companies. One of countless examples: the bundle of complex gas procurement contracts, storage for combined heat and power and district heating with additional condensing power extraction, all while meeting restrictions arising from CO₂ emission controls, control energy markets and spot markets.

Optimisation task packages like this are additionally faced with long planning horizons specified by product durations on futures markets (EEX up to 18 months). Under conventional optimisation methods, optimisation scenarios involving long planning intervals result in high calculation times. To reduce these times, a number of algorithms tuned to specific problems come into play. However, this then results in a lack of flexibility: integration of new trading products and variable contract types means that such algorithms must necessarily undergo extensive adjustment. The standard method of Mixed Integer Linear Programming (MILP) in combination with the branch and bound algorithm, which is applicable independent of the problem posed, guarantees decisive advantages.

PROMETHEUS solves complex deployment optimisation problems using Mixed Integer Linear Programming. This method finds the verifiable (global) optimum for a problem. PROMETHEUS has proven itself over many projects under multi-commodity conditions and operational constraints, and is devel-

Success comes in pairs: unbeatable PROMETHEUS calculation engine and aggregation methods at the speed of sound

oped, maintained and marketed exclusively by KISTERS. BelVis ResOpt exemplifies the performance characteristics proven with PROMETHEUS, and extends them with an additional modelling concept for arbitrary resource streams.

Completed! Closed optimisation for annual and multi-year planning with high temporal resolution

Coupled contract and operating conditions such as e.g. energy quantities (take-or-pay, summer quantities), demand charges and the number of starts force closed optimisation over multiple years on the basis of hourly values. On standard server systems, it is no longer possible to incorporate the necessary volumes of data and correlations into the calculation within the required calculation times. The solution, the temporal decomposition of

the problem and the associated successive optimisation of subproblems, is already practice for these large optimisation scenarios in BelVis ResOpt: easily and flexibly configurable aggregation automatically condenses comprehensive optimisation models, and expands them again later. The stepwise compression remains accurate and consistent with regard to energy quantities and load spikes. The aggregation and the resulting savings in calculation time mean that the optimisation models may be solved even on standard PCs. Stepwise calculation in hourly or daily steps is also possible, in order to obtain a detailed statement on specific time slices.

In step 1 of this multi-step aggregation process (schema in Figure 4), large time intervals are established, for which

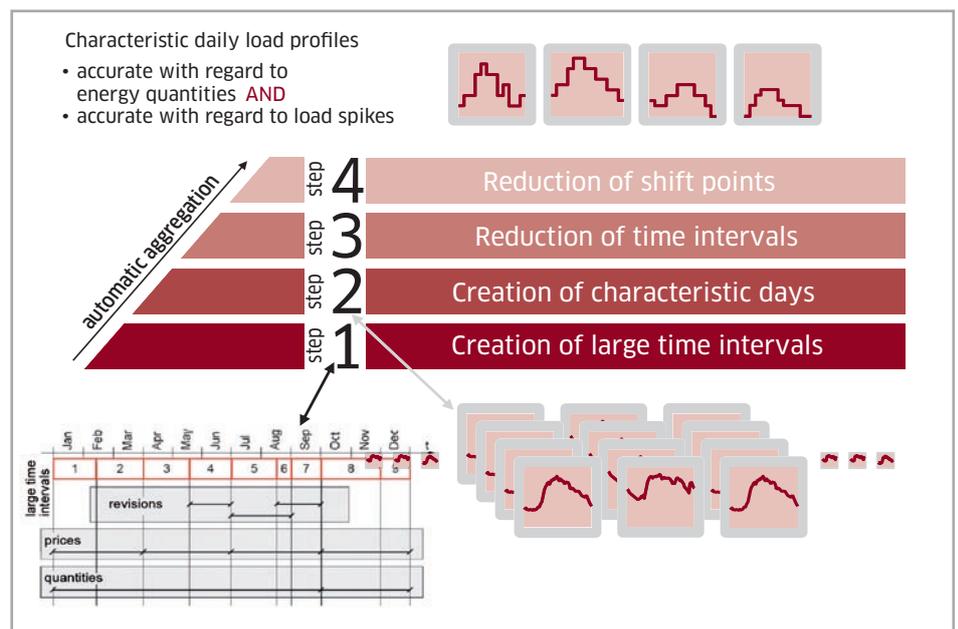


Figure 4: Aggregation method for rapid solution of large optimisation models

Solutions with BelVis ResOpt

Asset deployment optimisation for power plants

Power plants are a part of the generation portfolio, which encompasses the interconnected nature of economic activities in the generation sector and includes the power plant facility, regular supply contracts, network transfers with their restrictions and the market models (e.g. for power, control energy, steam and heat). From the point of view of generation, BelVis ResOpt deployment optimisation should be integrated in the market processes for bid proposal, schedule creation, schedule handover and gas nomination to efficiently and effectively serve the deployment of primary energy.

The optimised portfolio can be integrated into generation sector business processes spanning from long term planning (e.g. risk management) to medium term annual planning right through to daily planning (day ahead and intraday). The coupling of long term and short term planning tasks is implemented through workflow control and corresponding time series structures for the variants and scenarios in BelVis.

Management and optimisation of virtual power plants

The potential to build pools allows operators of smaller plants to participate in the provision of minute reserves and benefit from the associated financial advantages. In addition to network substitute aggregates, minute reserve marketing may also be highly lucrative for combined heat and power plants. The combination of several plants into a block product of four hours allows the operator of a thermally operated plant with correspond-

ing storage and intelligent optimisation to participate in this scenario within the framework of a virtual power plant.

BelVis ResOpt takes care of the optimisation of the virtual control energy plant. BelVis ResOpt handles automated deployment optimisation of CHP plants. It follows the goal of maximising revenues from minute reserve services, and defines the daily available minute reserve power that is held by CHP plants for later provision. The schedules for optimised overall operation are established on a 15 minute grid, ensuring provision of the minute reserve power.

With the increasing number of plants and the combination of minute reserve power and power production, pool operators are faced with the question of how to achieve economically optimal operation of the pool. BelVis ResOpt optimises the entire minute reserve pool with a view to maximise the profit contribution.

Gas portfolio optimisation

The economic activities of gas trading result in a portfolio consisting of regular supply contracts, sales contracts, storage, network transfers with their restrictions and the market models (e.g. spot and future market within the framework of the gas market model). From the point of view of trading, BelVis ResOpt portfolio deployment optimisation should be integrated in the market processes for long and medium term planning, bid proposal and gas nomination to efficiently and effectively serve the deployment of gas assets.

Of course, asset deployment and portfolio

optimisation may also be combined in BelVis ResOpt, for example to optimise CHP systems with complex gas procurement options.

Metallurgy optimisation

In the field of metallurgy, oxygen is injected to improve combustion processes during iron making; during further processing into steel, oxygen also serves to oxidise excess carbon contained in the pig iron. Because the pure oxygen is often purchased from external suppliers as required, use of oxygen generates both costs and savings in fuel demand. Coke oven and blast furnace gas arise as a by-product of the metallurgic process, which may be stored or used to generate power and heat.

To achieve the most economical operation possible in the smelting works, BelVis ResOpt both optimises oxygen procurement and plans optimal deployment of the resulting gasses, thus significantly reducing dependency on external gas procurement. The system considers the multifaceted correlations between the topologically distributed gas producers in the metallurgic process, the use of oxygen and the consumers of gas, as well as the own plants and external markets. The BelVis ResOpt model represents the resource streams in gas systems (coke oven gas, blast furnace gas, natural gas), flows in the oxygen system, the heat and steam system as well as power flows. The goal is to achieve minimal costs and/or the best possible efficiency of the deployed resources.

the same contractual and operational boundary conditions hold. These may be, for example, the same prices for fuels and contracts, the same availabilities and revisions, or the same energy quantities or demand charge conditions. In step 2,

BelVis ResOpt! Your optimum of optimisation

characteristic days (with comparable load characteristics) are combined within the same large time intervals, whereby the energy accuracy of the substitute model is secured with record of the maximum power. In doing so, the entire calculation time range is broken down into subranges with comparable daily load profiles and boundary conditions, while observing the power limits, plant-specific energy quantity conditions and other time integral conditions, such as the residual load utilisation period and operating period. Operational diagrams, characteristic curves, minimum operational, idle and revision times are maintained. Storage capacity, loss, parameters and stages are represented correctly. A reduction of the time interval and shift point may additionally be carried out in steps 3 and 4. This proven method of aggregation may be applied decisively with large models to solve technical problems, as the calculation work is reduced significantly. For users, this additionally means that all planning intervals and tasks may be calculated based on the same mathematical optimisation model. This reduces the adjustment effort necessary during model preparation, and results in more comprehensible results on the basis of established and consistent fundamental assumptions.

The special features of mathematical optimisation with BelVis ResOpt and PROMETHEUS:

- closed solution to the whole mathematical problem through use of leading mathematical solvers (e.g. IBM ILOG CPLEX),
- optimisation of large models and time intervals through automatic aggregation over various time periods,
- proof of the optimality of the found solution,
- a detailed statement on individual time slices,
- the reproducible result over all time intervals,
- solvability of the optimisation task on standard PCs.

These features guarantee an overall optimisation solution which sums up the range of decision options with regard to economic benefit.

The discovery of the skin effect.



Stable cable with low resistance. This concept would have remained a dream without Nikola Tesla's discovery of this exceedingly important principle for high-frequency alternating current. Tesla discovered that alternating current does not flow in the middle of a wire or similar conductor, but along its surface. This effect, known as the skin effect to modern engineers, is applied today in the form of steel cable with a copper mantle. The steel provides strength to the cable, while the copper offers a lower resistance to the flow of electrical current. Every user of electrical power today has benefited from Nikola Tesla's spirit of research.

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