Digital Twinning for Geothermal Power Systems

ICELAND: RENEWABLE ENERGY AND SUSTAINABILITY CAPSTONE

THE GREEN PROGRAM
EDUCATION ABROAD. REDEFINED. REINVENTED.

ICELAND SCHOOL OF ENERGY
REYKJAVIK UNIVERSITY

TWINNER ANALYTICS

United Nations Sustainable Development Goals

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Business Model

KEY CUSTOMERS

Landsvirkjun
National Power Company of Iceland

Orkuveita Reykjavíkur

ORKA NÁTTÚRUNNAR

KEY PARTNERS

Háskólinn í Reykjavík
Reykjavík University

ÍSOR

EFLA

KEY ACTIVITIES

Provide real time **monitoring and predictions** using machine learning and digital twinning.

KEY RESOURCES

Existing sensors
Existing data
Software Engineers
Site Engineers
Facility Managers

VALUE PROPOSITION

Digital Twinning has a potential economic impact of 160 billion to 930 billion by the year 2025.

50% Improved Equipment Maintenance

35% Operations Optimization

10% Health and Safety Management.

5% Others

COST/REVENUE STRUCTURE

Cost: Cost of hiring a team of engineers

Revenue: Charge customers a flat fee for a basic package and premiums for extra functionality.

DISTRIBUTION CHANNELS

Business to business distribution channel in the form of analytics software packages

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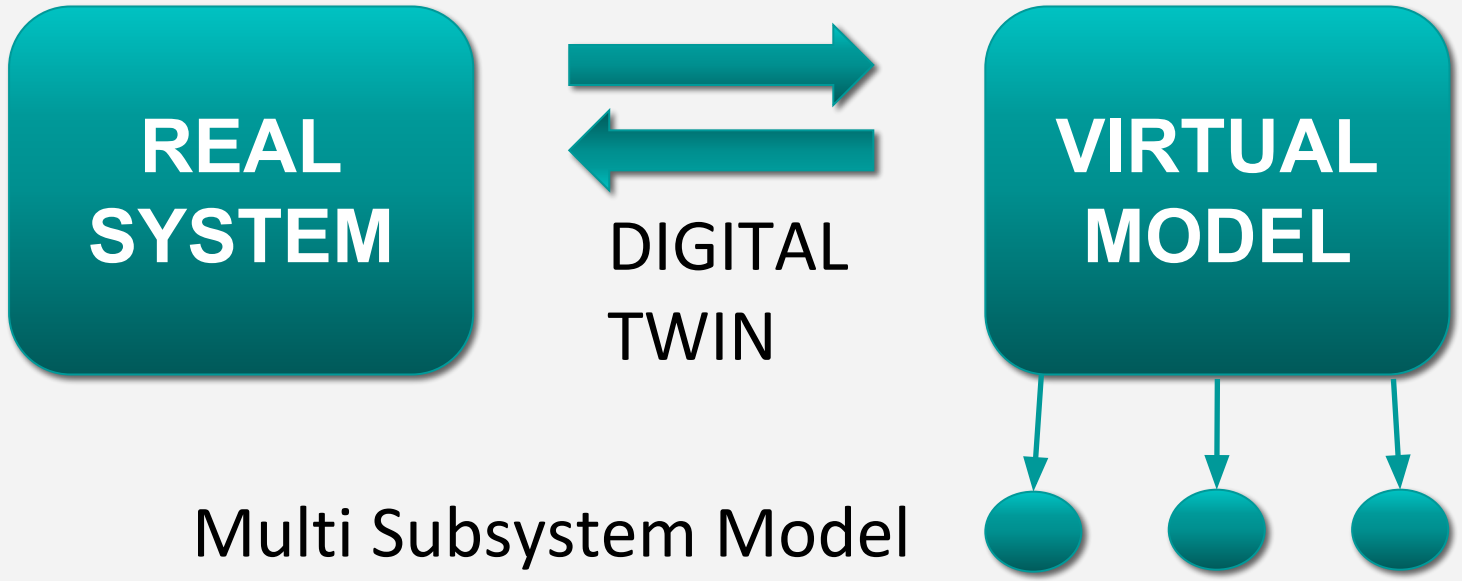
Business Drivers

Key Concepts

Digital Twins

Machine Learning



Multi Subsystem Model

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Formula 1 Racing

- Data is collected starting from the Friday practice, which helps set up the car for the race
- During the race data is sent in real time to the pit wall, and in the background simulations are run w.r.t the current racetrack and car conditions
- The race strategy is dictated based on predictions of the simulations
- Post the race weekend, the collected data is fed into predictive models, combined with existing data sets to create new plans and update the models

What is currently being done?

- **Natural State Model**

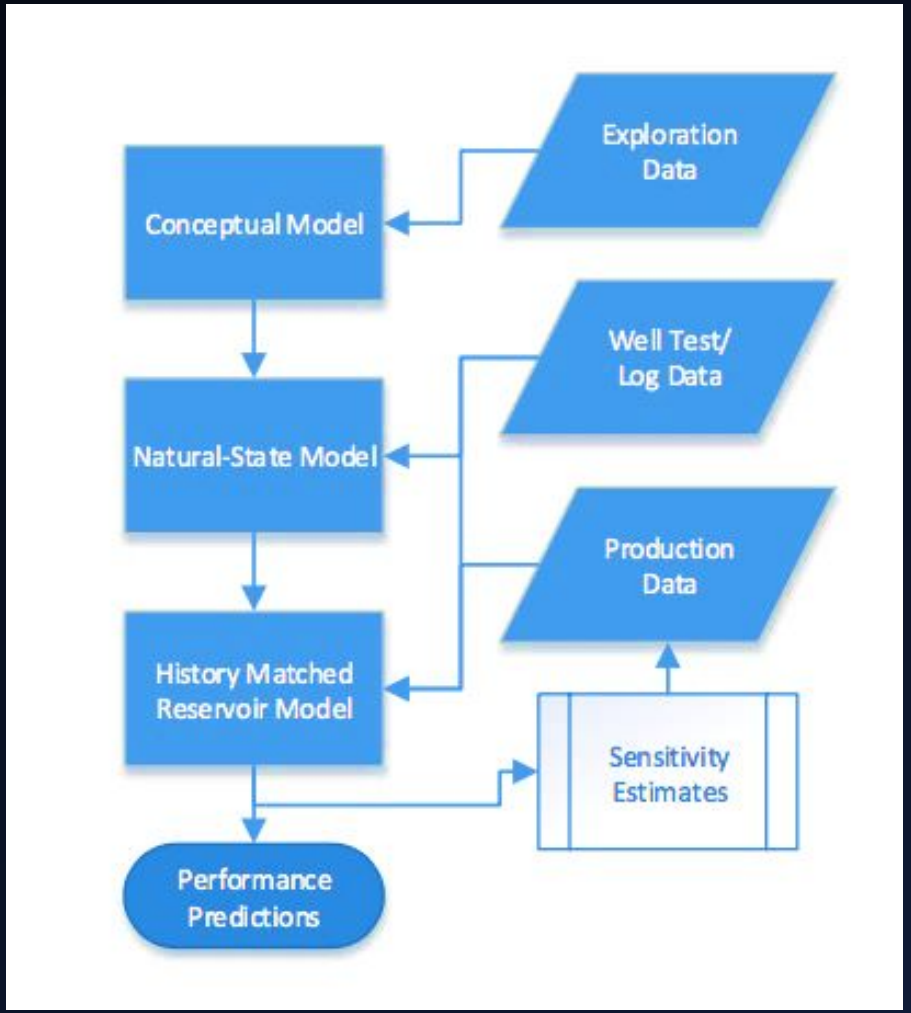
Reproducing the estimated formation pressure, temperature and enthalpies prior to utilization.

- **Historical Data**

Matching the changes of pressure, temperature, enthalpy and chemistry during production.

- **Predictive Data**

Forecasting the future performance of the reservoir. Using sensitivity estimates to decide on further data acquisition



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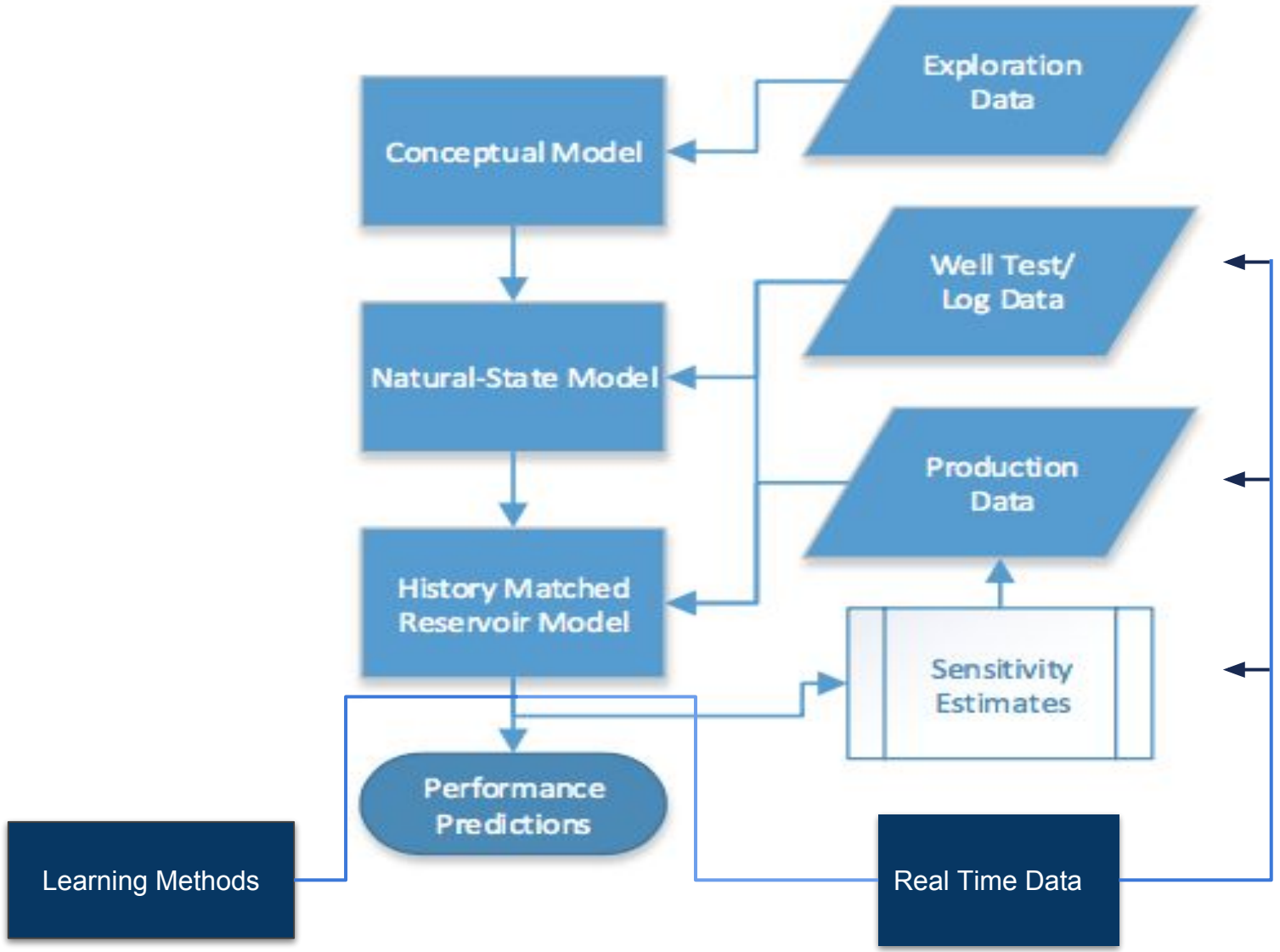

Compare predicted and actual values to update the models accordingly

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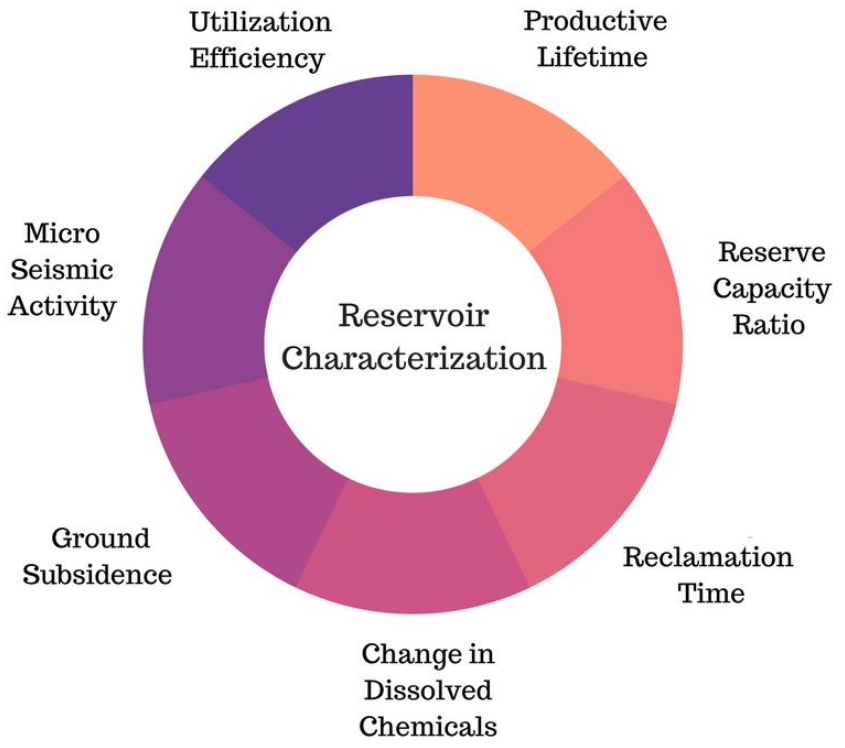
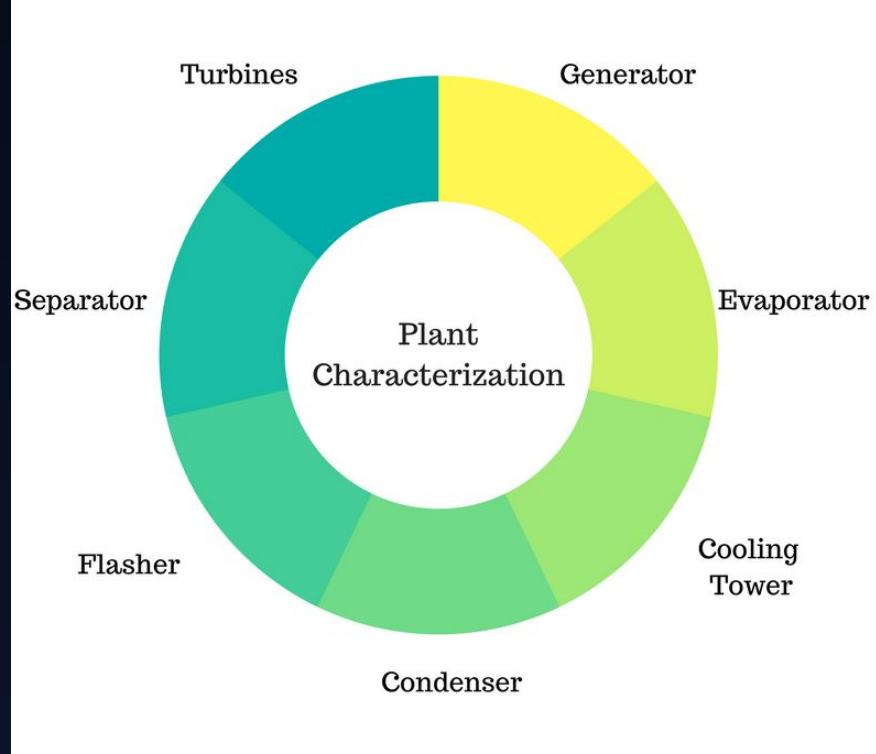
Digital Twin Indicators

PHASE 1



PHASE 2



Source: Sustainability evaluation of geothermal systems in Iceland. Rut Bjarnadottir, 2010.

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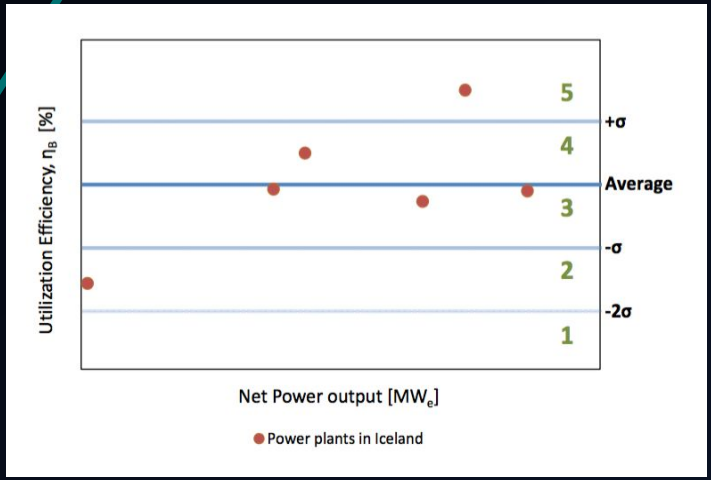
PHASE 1

Efficiency Use

Measures how well is the extracted fluid is being utilized. Requires exergy analysis.



Productive Lifetime

Time that a reservoir can sustain a certain level of production.

Production can cause changes in the physical conditions of the fluid in reserve...

Reclamation Time

Time the reservoir takes, based on pressure and heat, to recover from production.

Reclamation Time

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Productive lifetime

Source: Sustainability evaluation of geothermal systems in Iceland. Rut Bjarnadottir, 2010.

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PHASE 2

Process involves high cost machinery and tools

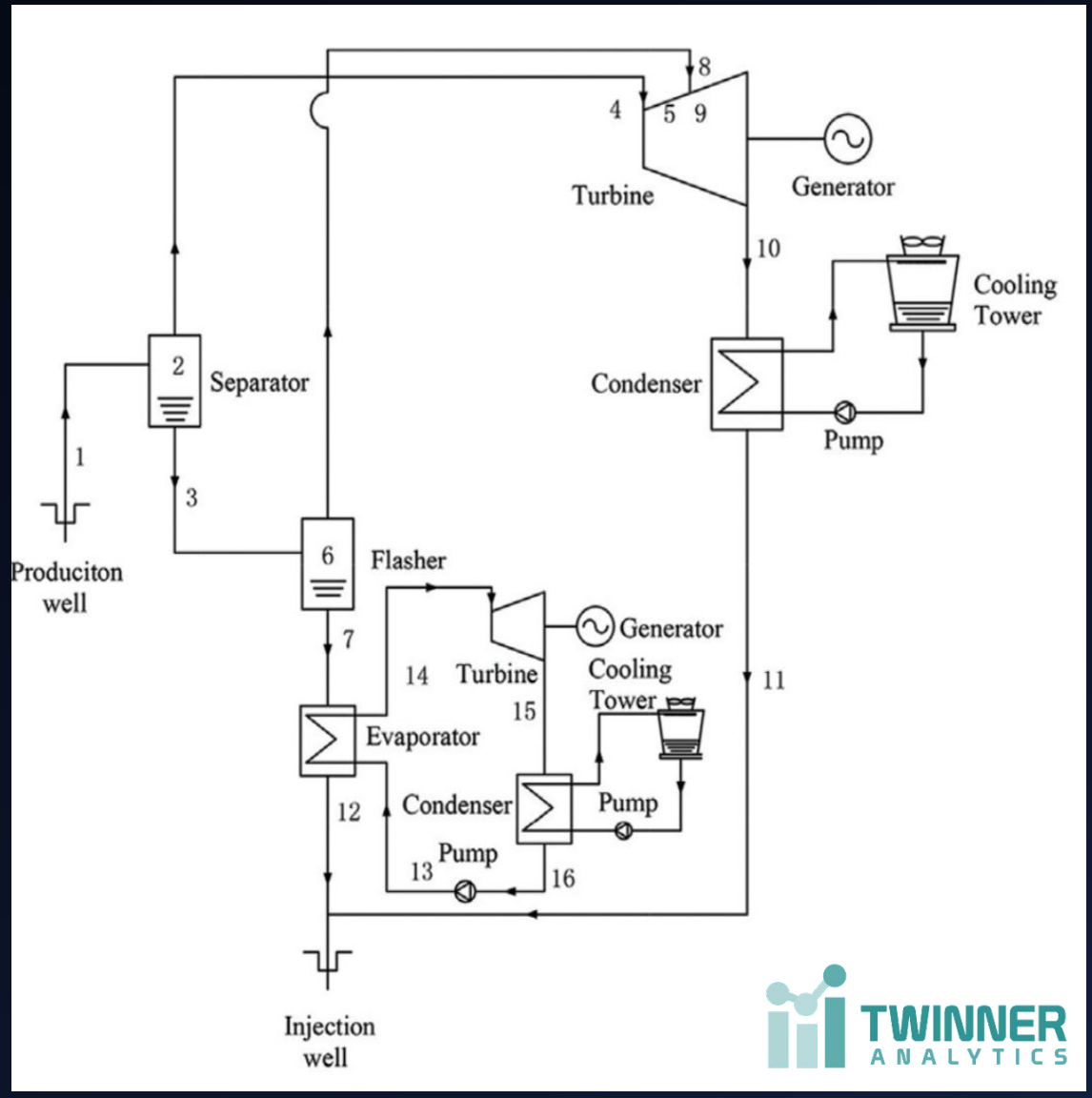
- Any failure leads to high costs and non-productive time
- Every operational mistake is high cost

The operations have a lot of unpredictability

Models not updated in real time lead to poor performance

What will we offer?

Sensors at each component of the geothermal system to track the performance



Sample Features

Geothermal Power Analytics: Calculate important performance metrics such as annual energy production, capacity factor. Give monthly energy production, individual component characteristic, climate data, as well as analyze trends on customer side and production side.

Mean Time Between Failure: Process multiple components from different sources and provide the reliability estimates for each component and analytics about degradation of system over time.

Bayesian Change Detector: Detect anomalies in the time series data - Detect faults in machines by analysis of continuous flow of sensor data produced by the machine.

Failure and Event Driver Identification: Identify the key drivers relevant to the specified event or failure from a large set of attributes and changes that occured in the system. Interplay between reservoir changes and plant failures.

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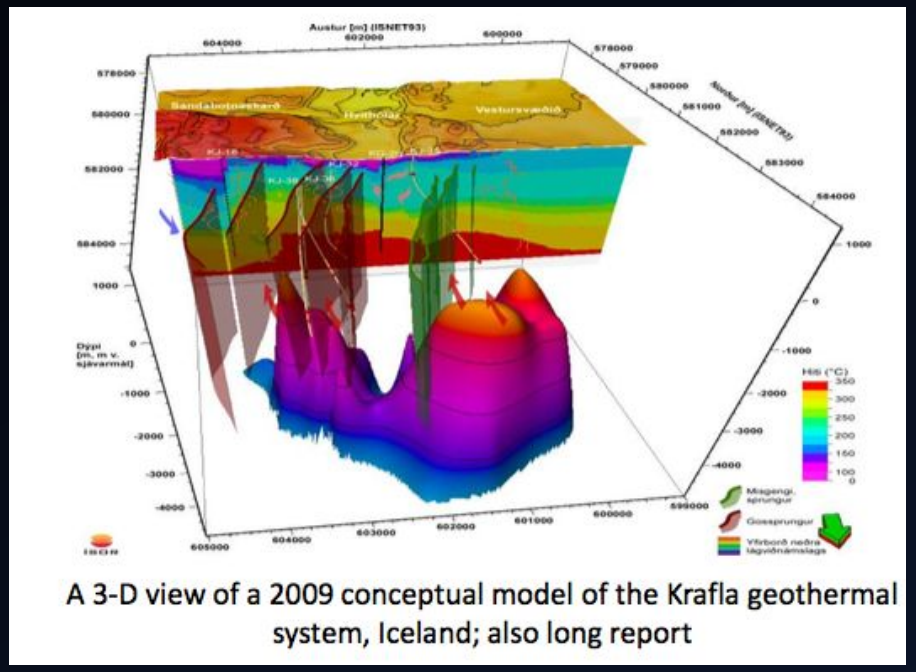
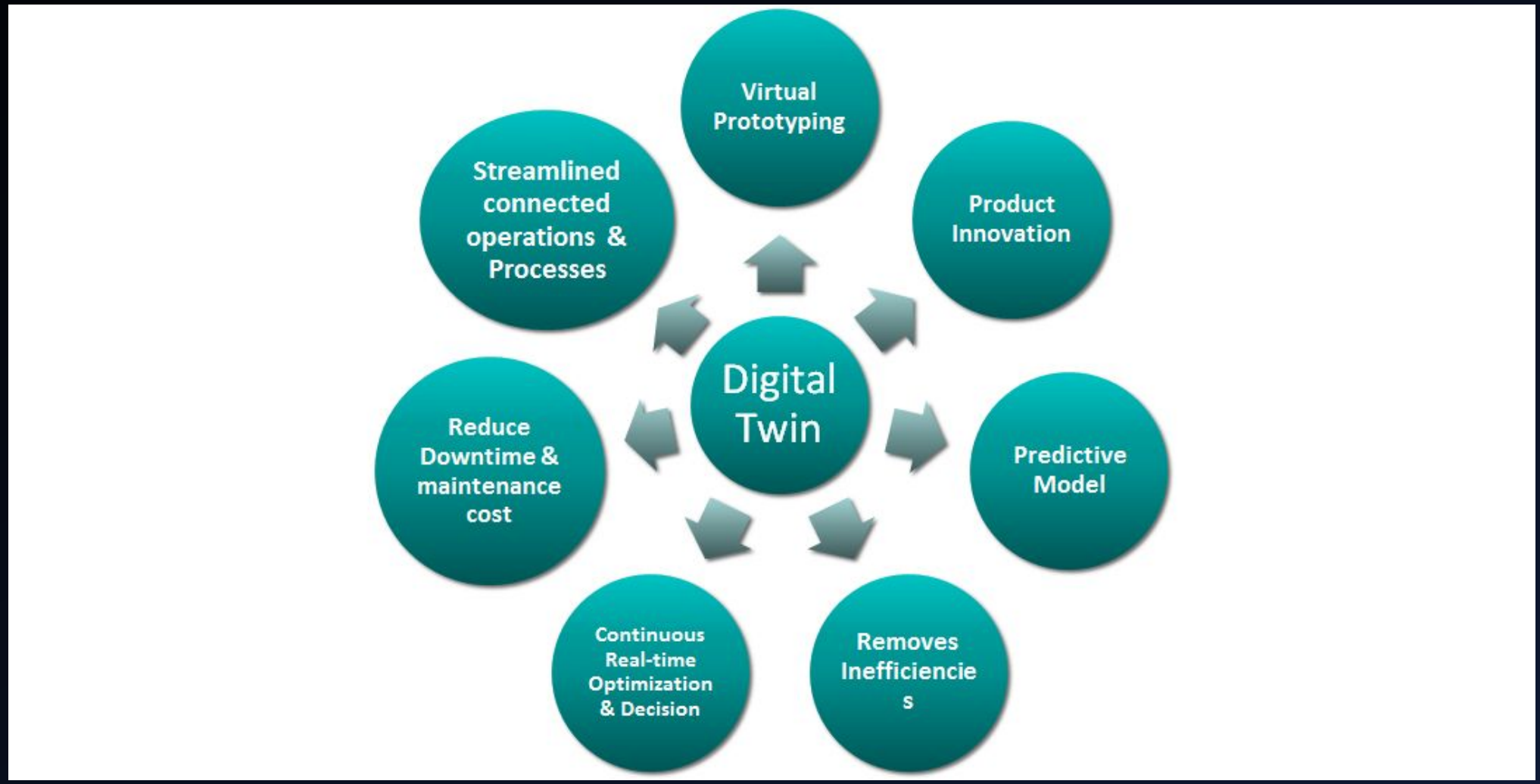
Advantages

Better prediction and increase in performance of the entire system.
Determine failures before they occur both in reservoir modeling and Plant systems such as turbine, separator, condenser and cooling systems.



A 3-D view of a 2009 conceptual model of the Krafla geothermal system, Iceland; also long report

Advantages



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Challenges

- Data Quality (Need more live data acquisition for accuracy)
- Different plant systems have different component and sensors
- Different kind of Reservoir characteristics
- Funding and resources (sensors and computing required)

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Vision for the Future

We envision a dynamic model that:

- Continually collects a significant amount of data about each individual component in order to create a model of that behavior
- Implements analytics that use the individual models to derive smart business outcomes by learning from past results and data patterns
- Combines modeling and analytics techniques into a platform that simplifies and accelerates their use allowing these capabilities to be easily adapted for new services or other industry applications.

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Thank You !

“ A digital twin is a living model that drives business outcome”
(Colin J. Parris, GE)

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