Analysis of Advanced Process Control for Grinding

Johannes Sikström

SENIOR DEVELOPMENT ENGINEER

BOLIDEN MINES

Boliden Mines

Company Overview

5 mine sites in Sweden, Finland and Ireland

Purpose

Provide metals necessary to improve society for coming generations

Vision

Most climate friendly and respectable mining company in the world

Use case

Motivate and evaluate

Challenge

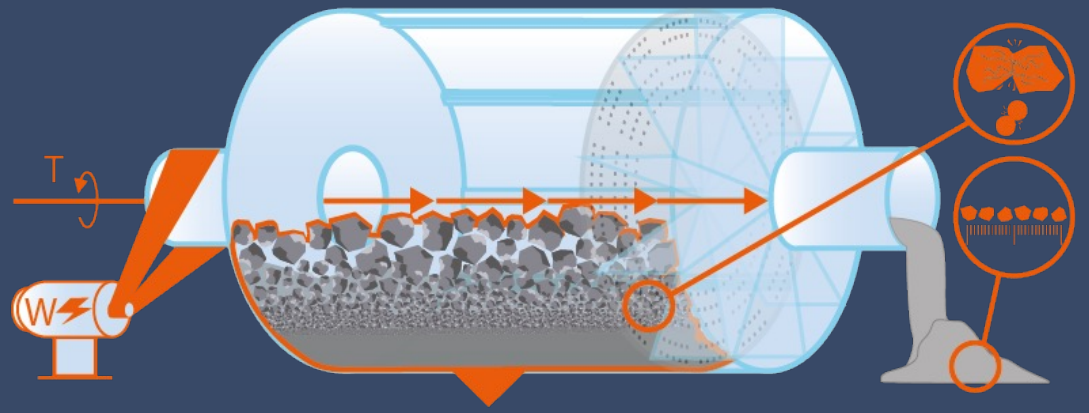
To first motivate and later evaluate new control implementation

Solution

Seeq analysis of potential and verification of final performance

Results

Project was motivated and successfully implemented.
Workflow improved
Control evaluation ongoing



BOLIDEN

Use case intro

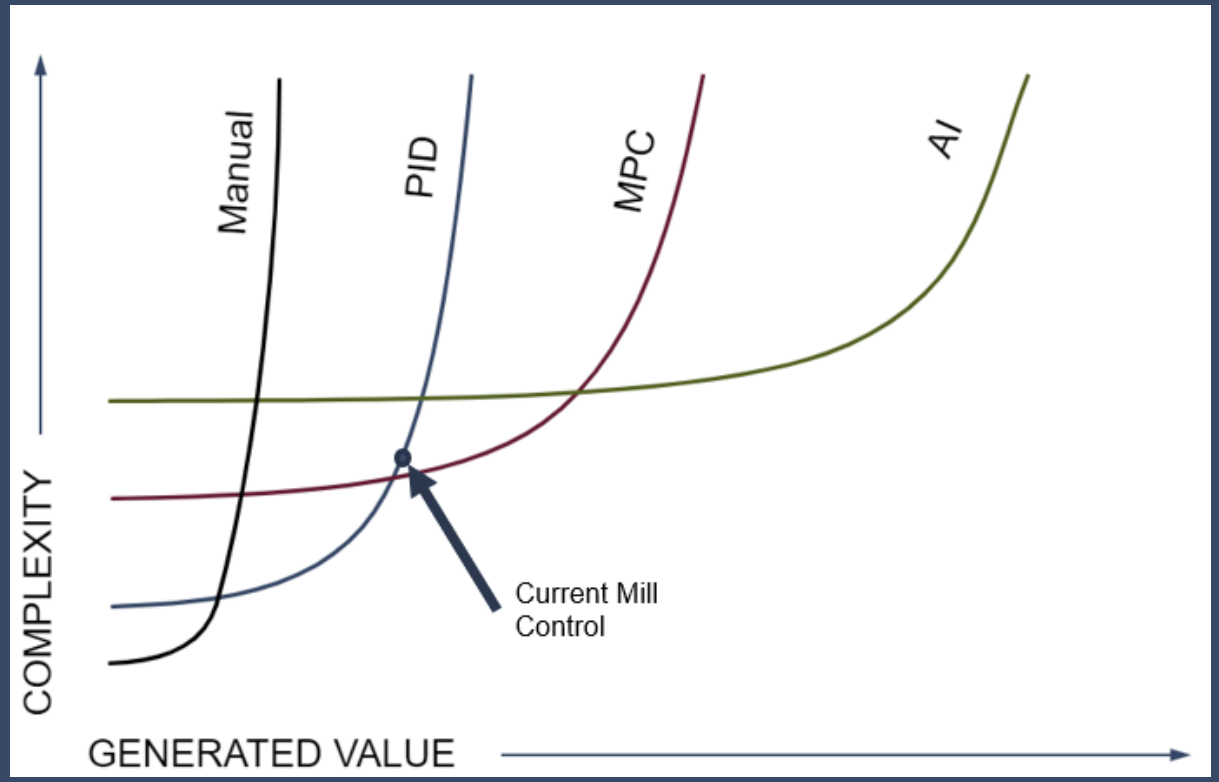
- Story of a series of projects
- Not the most technically advanced (and that's the point)
- This type of Seeq usage is currently creating most value at Boliden Mines
- Performing analysis is easy => more time thinking about **right analysis**
- Internally (to much?) focus on use cases

/imagine "Mill analysis in sketch style" (by Midjourney AI model)

Value creation through new technology

New Tech = New opportunities

- By shifting to a more capable technology, we unlock potential for more value creation
- **Seeq is used to motivate the ”jump” by quantifying the value**

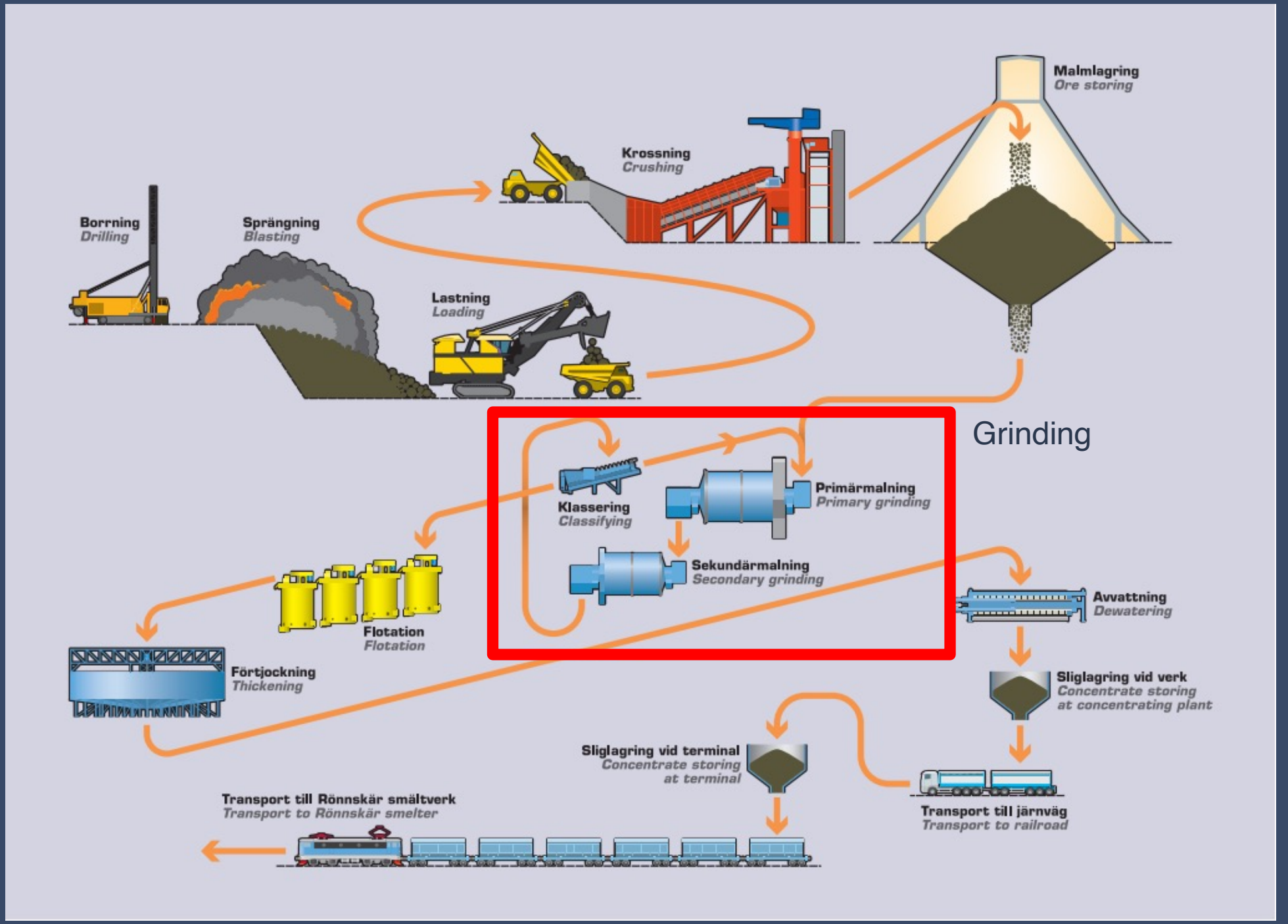


BOLIDEN

Mining

Grinding is

- Energy intensive!
- **Bottleneck**



Grinding

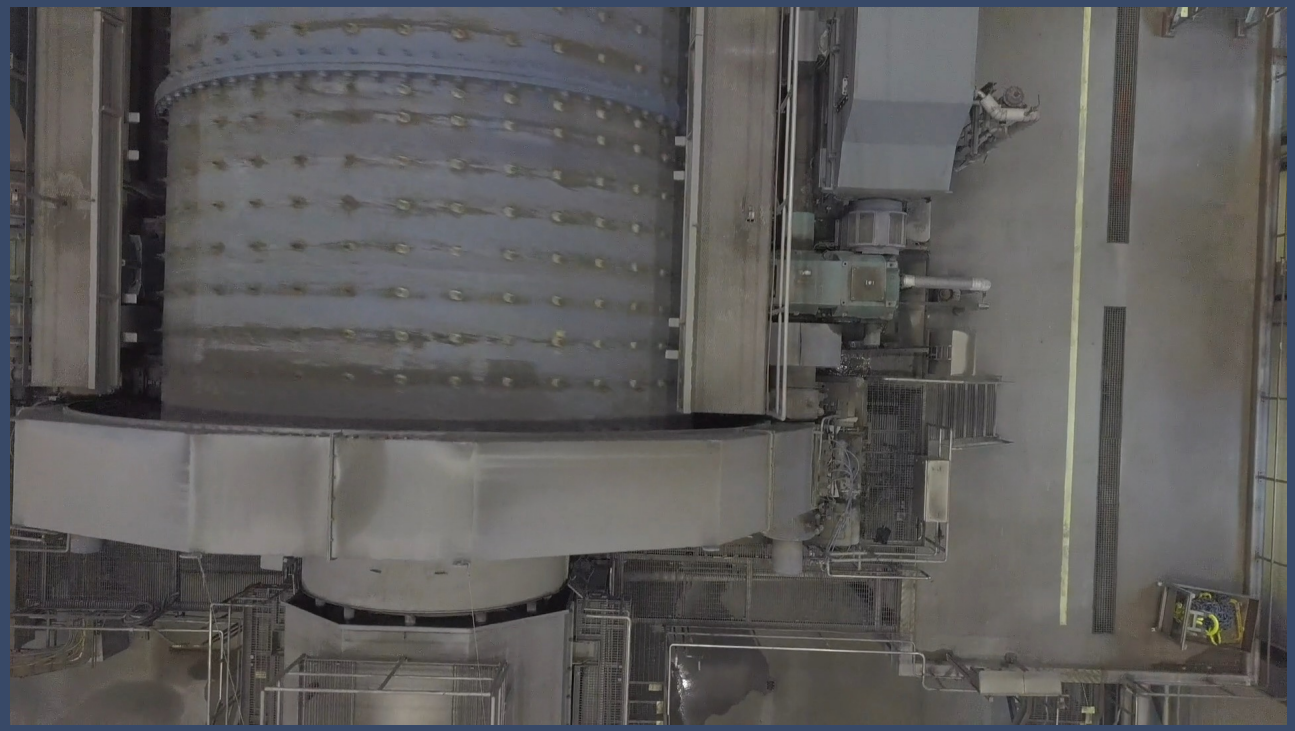
Quick intro

Don’t minimize energy use – Maximize it!

Utilize 100% of installed power (if possible)

Garpenberg has 2 mills with 5+2.5 MW installed power

Specific Grinding energy [kWh/t]



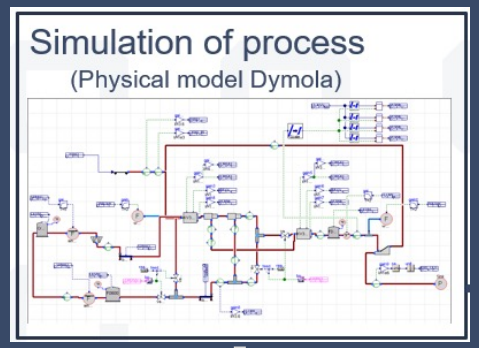
Higher kWh/t = Higher ton/h and/or finer grind = More product and higher recovery = $$$

First step

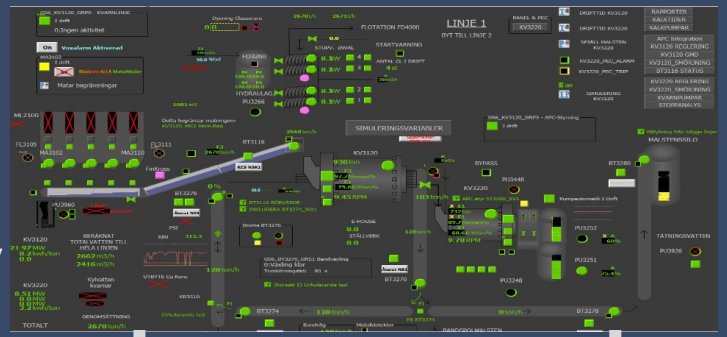
Benchmark R&D-project

Using simulated process to directly compare new and old control strategy

Indicating how much more **value** a new control could generate



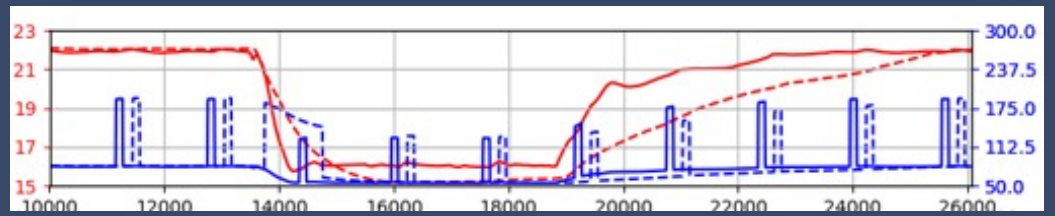
Full copy of DCS



Classical control (current)

Advanced Control (new)

Benchmark



What do we have today?

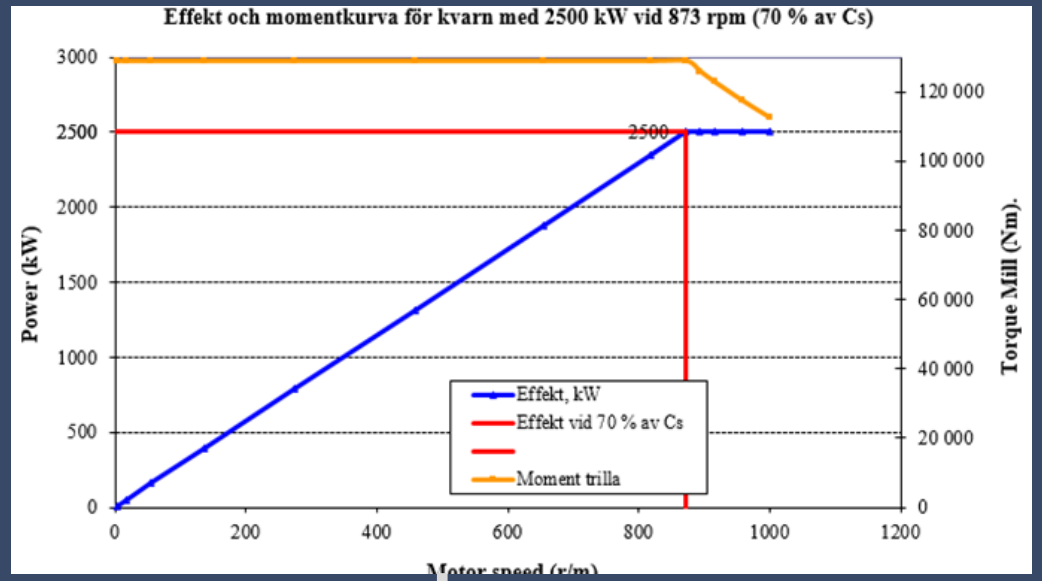
Establish baseline

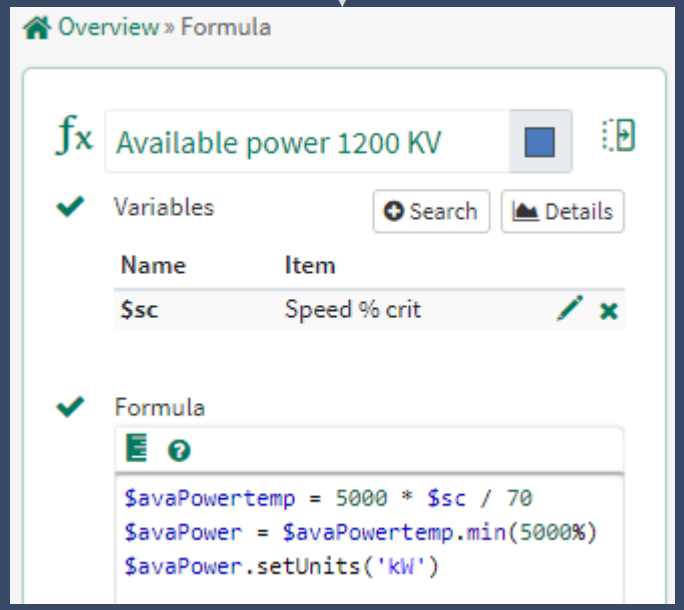
Example:
Separating *Absolute* from *Relative* power utilization

Due to engine design, full power not possible until the mill reaches a certain speed

Available power is speed dependent

Seeq unlocked new ways of looking at data





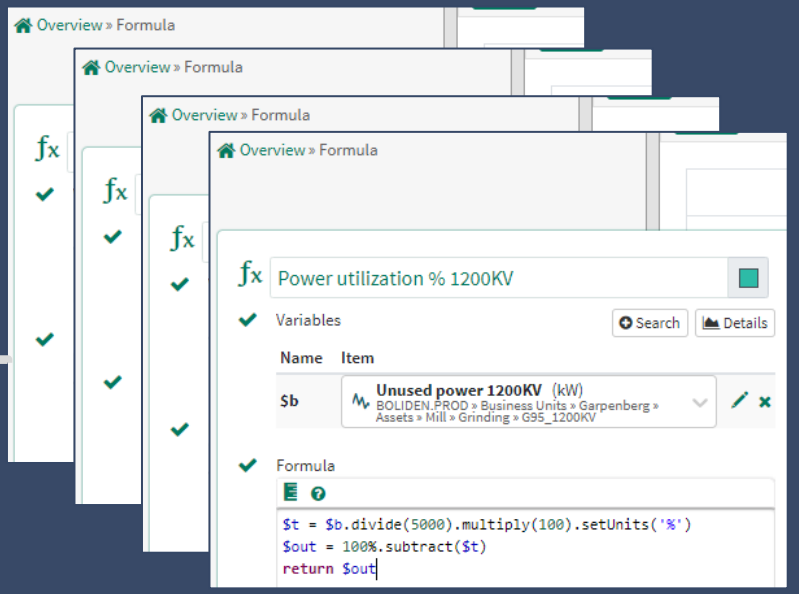
Visualize

Establish baseline

Motivating -> Use visuals

Don’t underestimate the value of visuals when presenting data

Used “live”



Power & Available power

Unused power

Unused energy re-calculated as potential grinding energy

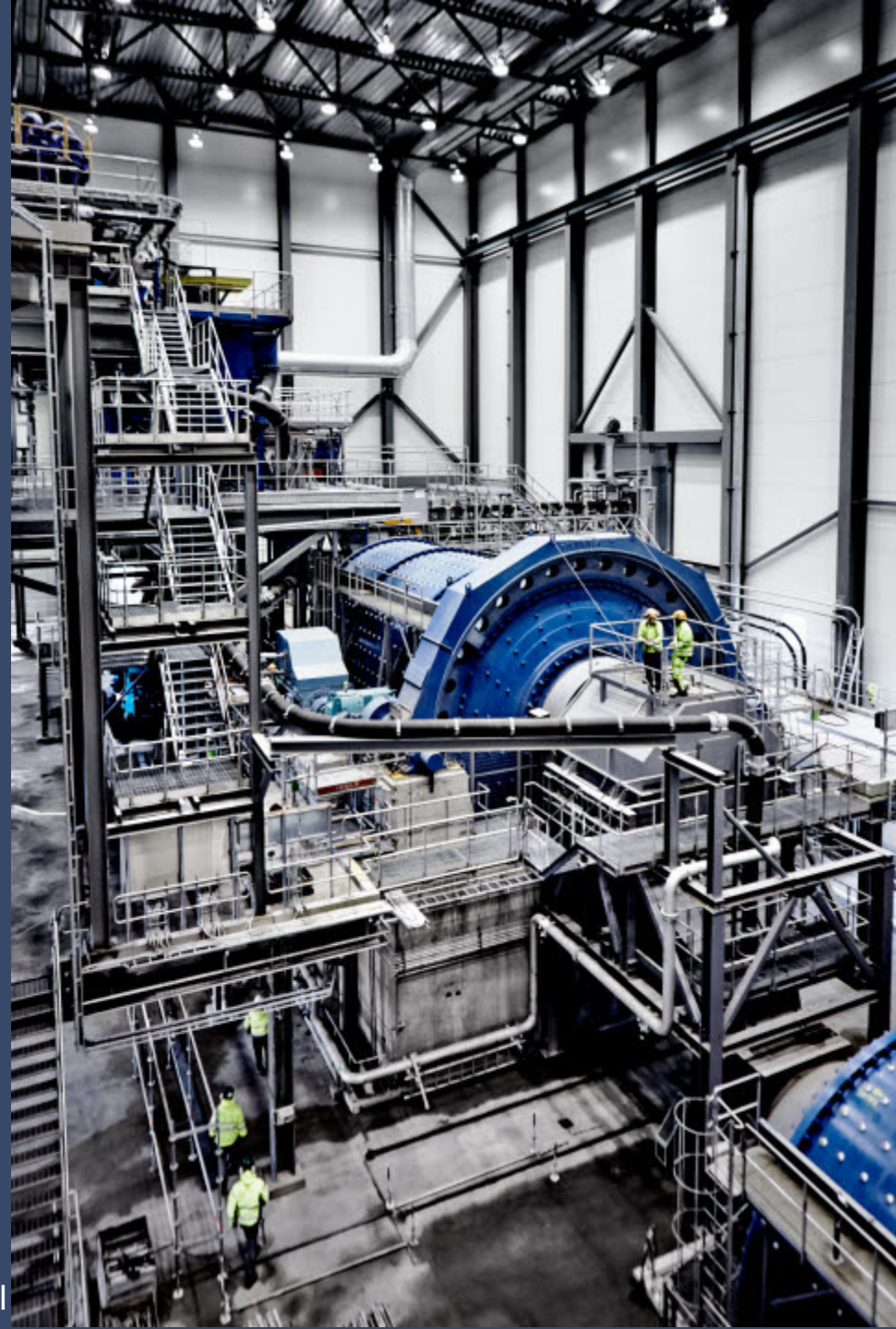
Baseline established

Establish baseline

- The baseline established
- Baseline + benchmark results -> implementation targets

>> Solid basis for decision

Next step: Implementation of advanced process control for the grinding circuit



Garpenberg Primary Mill

Implementation Project

Implement

Step tests
Building models
Installing code

On-site commissioning

/imagine “Large grinding Mill” (by Midjourney AI model)

Evaluation of new control

Evaluate and monitor

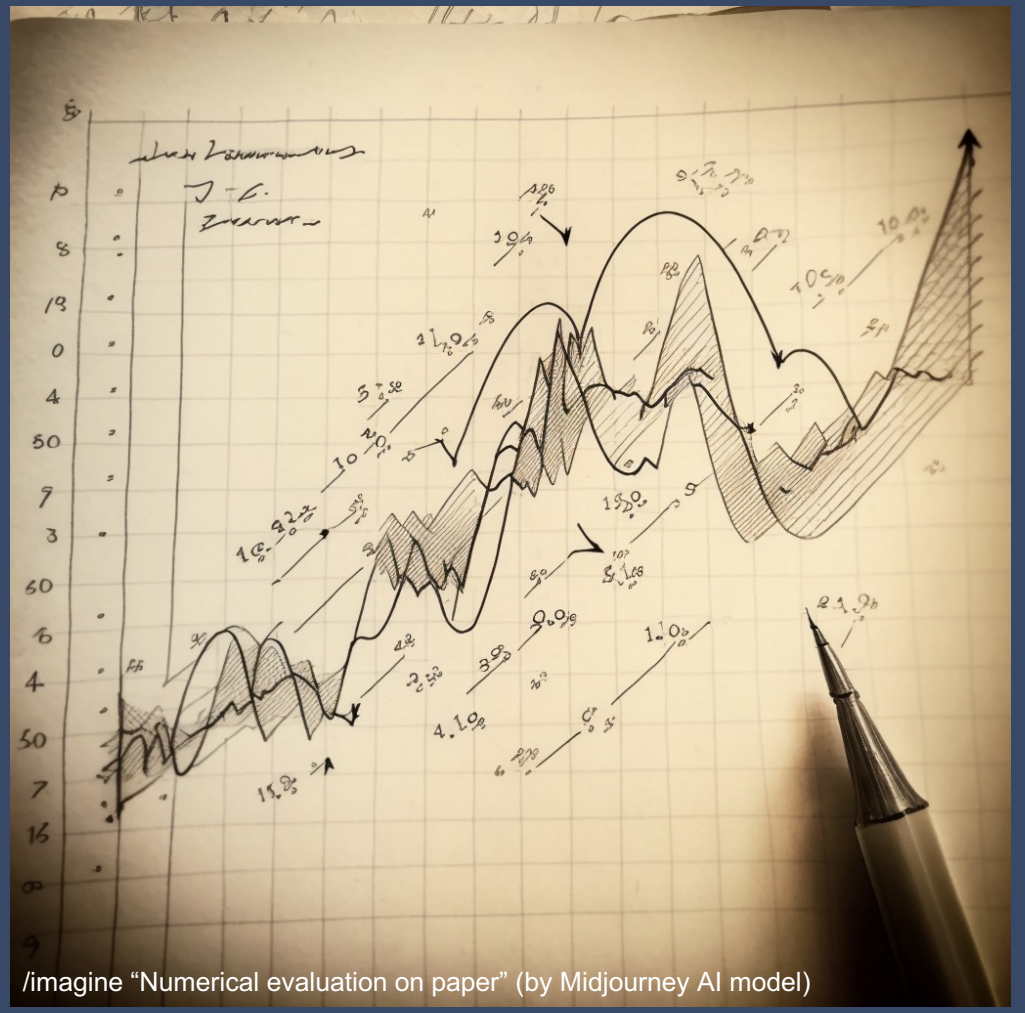
Analysis already done!?

Further build on analysis of baseline

Opportunities to think of different ways to look at the data

Improvement and refinement!

Add nuance



/imagine “Numerical evaluation on paper” (by Midjourney AI model)

BOLIDEN

What's limiting grinding?

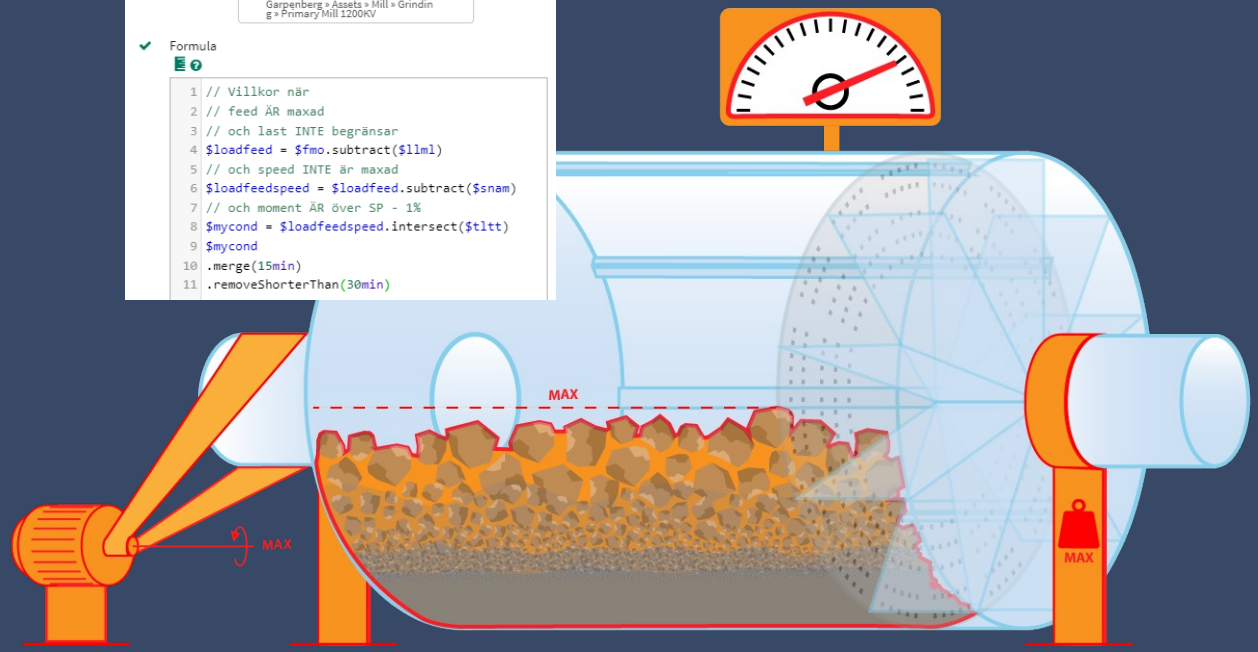
Evaluate

Determine the limitation
Power – Torque – Load – Feed

Combined conditions is the killer-app

We want torque/power to limit –
notice load limiting to much!

	Jan 2023	Feb 2023	Mar 2023	Apr 2023
Ave Feed Month (mill-running)	425.07 t/h	405.44 t/h	369.1 t/h	-
Mill Utilization	96.918 %	88.996 %	83.369 %	0 %
Feed Maxed Out % (Mill Running)	84.176 %	82.292 %	93.461 %	-
Mill Stops Monthly	8	13	6	0
Load Limited %-duration	38.907 %	35.189 %	53.831 %	0 %
Load Limited % (Mill Running)	40.145 %	39.54 %	64.569 %	-
Load limiting Torque % Monthly (Mill Running)	31.926 %	31.662 %	58.126 %	-
Torque Limited %-duration	32.329 %	23.081 %	12.801 %	0 %
Torque Limited % Monthly (Mill Running)	33.357 %	25.935 %	15.354 %	-



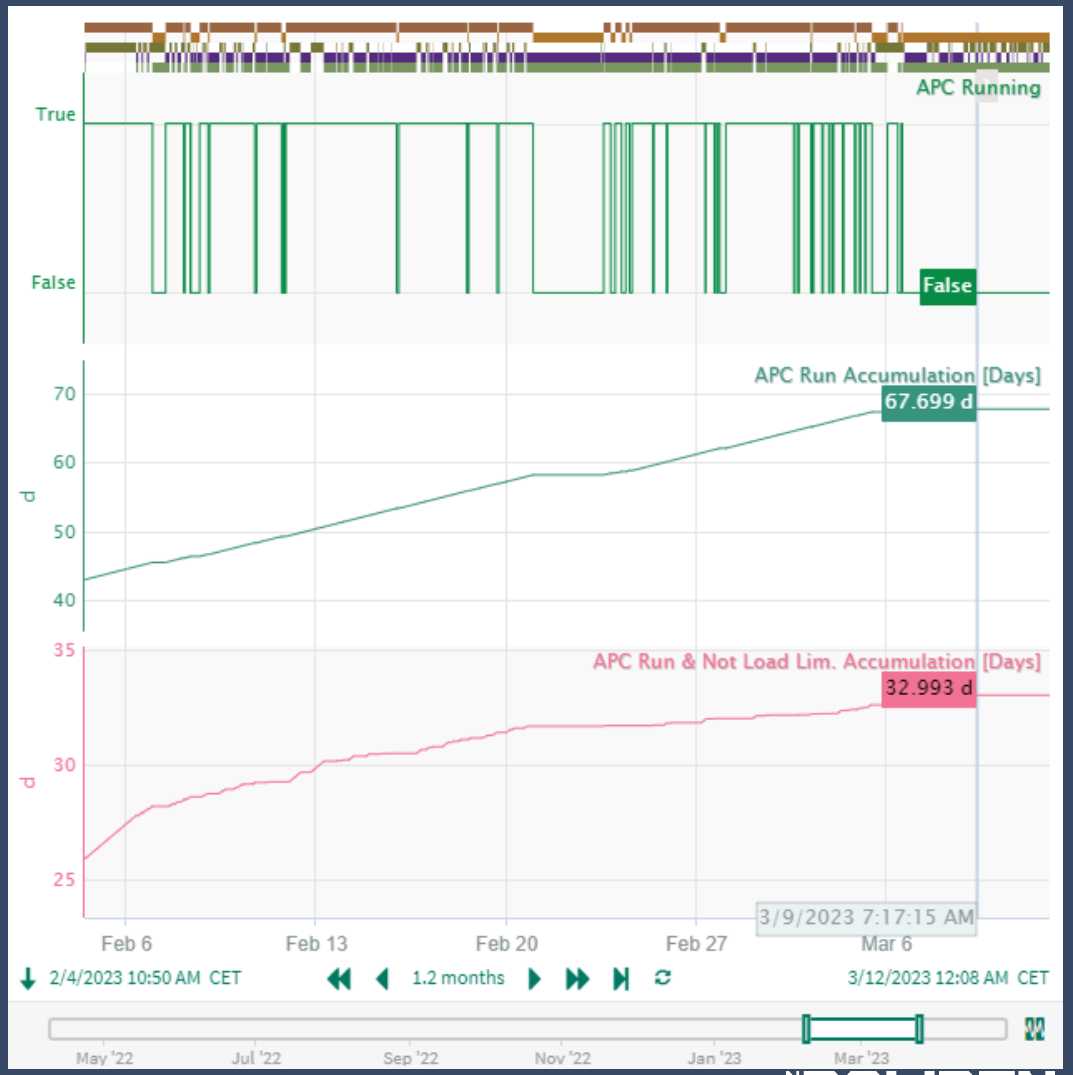
How much data is enough?

Evaluate

Setup monitoring on how much good evaluation data we have

Seemed OK, but removing conditions shows that little time is spent in good state for evaluation

Could be refined further

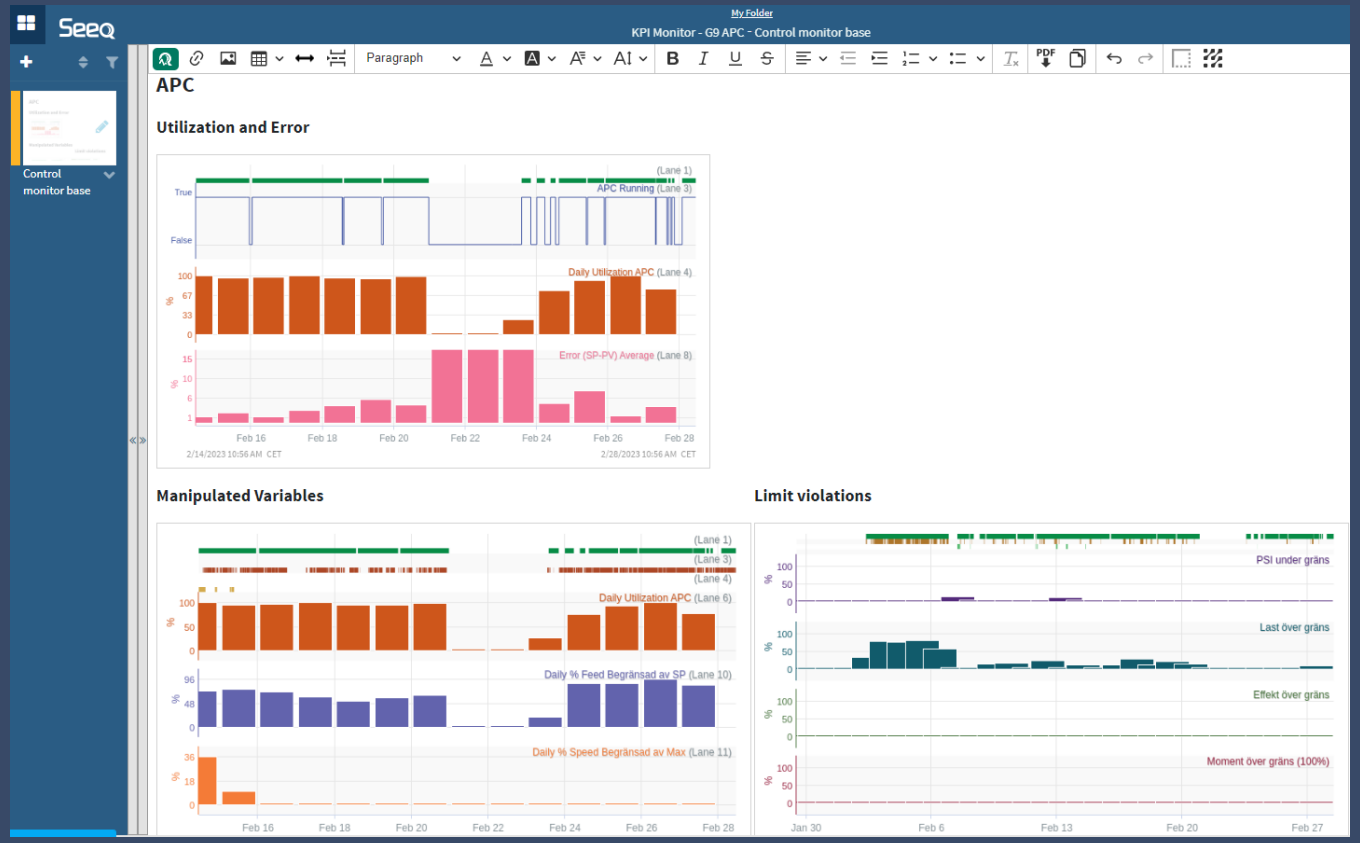


Monitor control

Topic for monitoring

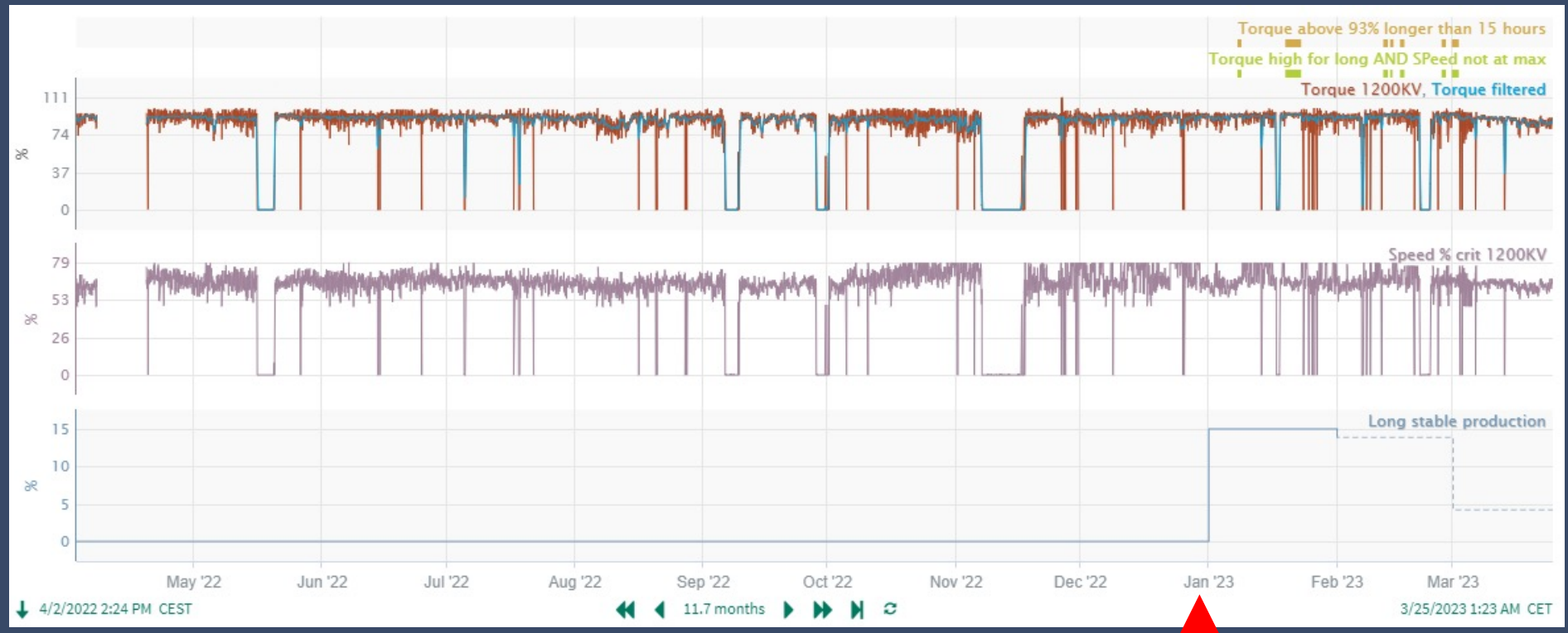
Topic to monitor control itself:

- Control Utilization
- Control error (SP-PV)
- Manipulated variables saturation
- Process variable limit violations



The *right* analysis?

Evaluate



"%-duration long periods of high sustained production"

New control implemented

BOLIDEN

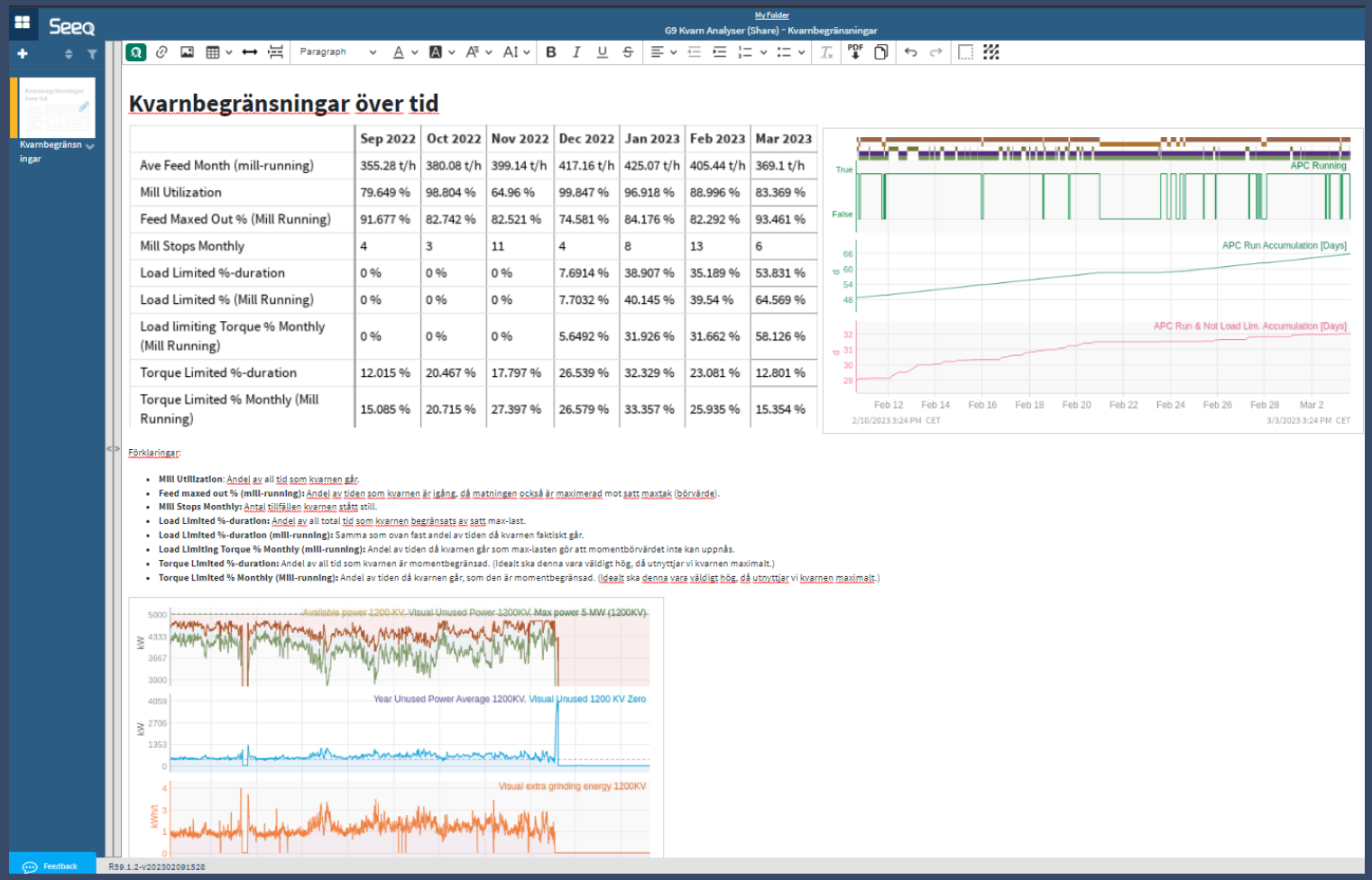
Topics part of delivery

Evaluate

With most analysis a topic is delivered to site

Track analysis or monitoring over time

Can be updated and improved as needed



	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023
Ave Feed Month (mill-running)	355.28 t/h	380.08 t/h	399.14 t/h	417.16 t/h	425.07 t/h	405.44 t/h	369.1 t/h
Mill Utilization	79.649 %	98.804 %	64.96 %	99.847 %	96.918 %	88.996 %	83.369 %
Feed Maxed Out % (Mill Running)	91.677 %	82.742 %	82.521 %	74.581 %	84.176 %	82.292 %	93.461 %
Mill Stops Monthly	4	3	11	4	8	13	6
Load Limited %-duration	0 %	0 %	0 %	7.6914 %	38.907 %	35.189 %	53.831 %
Load Limited % (Mill Running)	0 %	0 %	0 %	7.7032 %	40.145 %	39.54 %	64.569 %
Load limiting Torque % Monthly (Mill Running)	0 %	0 %	0 %	5.6492 %	31.926 %	31.662 %	58.126 %
Torque Limited %-duration	12.015 %	20.467 %	17.797 %	26.539 %	32.329 %	23.081 %	12.801 %
Torque Limited % Monthly (Mill Running)	15.085 %	20.715 %	27.397 %	26.579 %	33.357 %	25.935 %	15.354 %

Did it work?

Evaluate

Still not enough operational time

Initial indication are all positive!

Percentage points

+1.7%

+138 kW

+2.8%

+1.2%

OLD NEW

		Jun 2022 - Oct 2022	Dec 2022 - Mar 2023
Torque % 1200KV Period (mill-running)		89.597 %	91.343 %
Power draw Period		3959.8 kW	4047.5 kW
Power Draw Period (mill-running)		4166.4 kW	4304.3 kW
Relative Power utilization 1200KV Period (mill-running)		89.708 %	91.465 %
Absolute Power utilization 1200KV Period (mill-running)		83.329 %	86.086 %
Power Util. 1200KV relative to Torque SP Period		88.647 %	90.993 %
Torque Util. (not load lim) Period		95.316 %	96.488 %

Conclusion

Free up time to **think**

Add value to delivery

Value creation does not need to be technically advanced

Move analysis closer to process

Move users closer to analysis

/imagine “Time-series analytics inside processing plant” (by Midjourney AI model)


Thank you
SeeQ
CONNEQT