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Combining equipment health and production systems for increased uptime, production

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Digitalization and Automation in the Oil and Gas Industry – Challenges and Opportunities",
June 18, Tel Aviv, Israel

Safe harbor disclaimer

The information presented is intended to be an outline of general product direction and it should not be relied on in making a purchasing decision.
The information on the roadmap is for information purposes only, and may not be incorporated into any contract and is not a commitment, promise or legal obligation to deliver any material, code, or functionality.
The development, release, and timing of any features or functionality described for our products remains at BHGE's sole discretion.

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120 COUNTRIES	~70,000 EMPLOYEES	$23 BILLION COMBINED REVENUE*	125 YEARS OF EXPERIENCE

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Key Challenges for the Upstream Oil & Gas Industry

Increase Capital Efficiency & Profitability

Minimize Downtime

Reduce Marginal Cost

35% average recovery

13% average downtime

$8B in annual revenue opportunity per %

50% workforce retiring in 5-10 years

95% of data collected is never used

Digitize Knowledge of Retiring Workforce

Improve Health, Safety and Environment

Find Productivity Gains Hidden in Data & Workflow Silos

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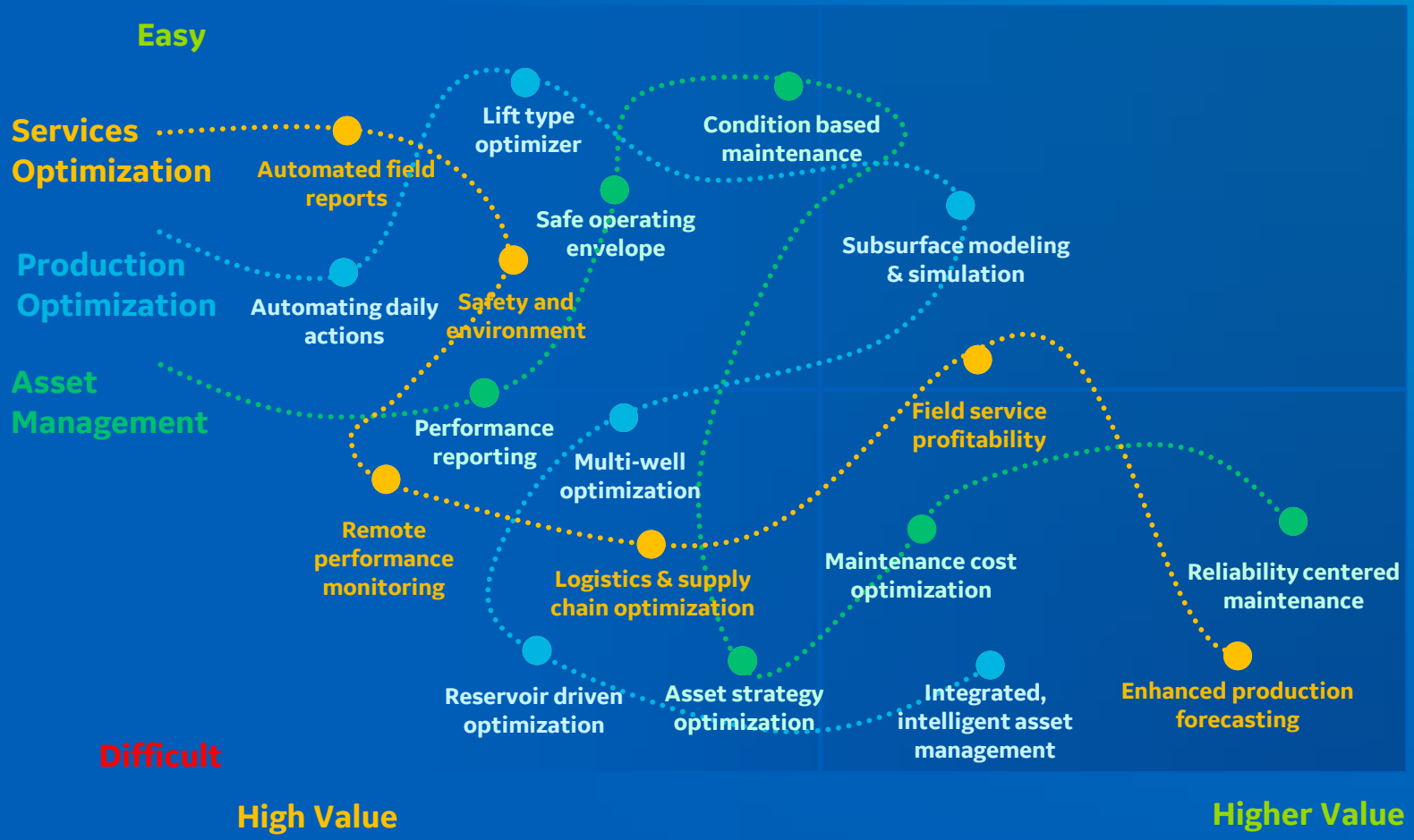
Advice for Digitalization

1. Think business, think technology
2. Think how, think what
3. Think old, think new
4. Think make, think buy
5. Think big, start small

How to define a Digitalization Roadmap



- **Use cases derived from valuable business outcomes define digital roadmap**
- **Need to balance achievability with aspiration**
- **Reuse of components required**
- **Always compare to checklist**
  - Span organization, assets
  - Cross functional governance
  - Break traditions
  - Redefined workflow/automation
  - Defined outcome

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Start with existing use cases/workflows – But challenge them!

Framework for Digitalization in Oil & Gas Production (I)

Understand the Past

Analyze historical information

Key elements
- Data quality
- Virtual meters
- Analytics
- Visibility (single version of truth) across the O&G value chain
- Root cause analysis
- Capture lessons learned

Monitor the Present

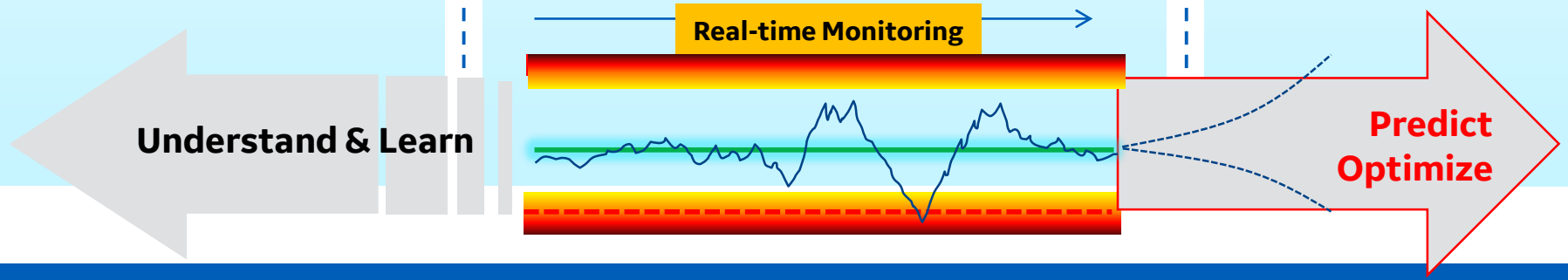
Detect anomalies and promptly evaluate corrective action

Key elements
- Data quality
- Virtual meters
- **Real-time** Analytics
- **Early anomaly detection**
- **Alerts**
- **Recommendations**
- Visibility (single version of truth) across the O&G value chain
- Root cause analysis

Predict & Optimize the Future

Forecasting/Optimization

Key elements
- **Probabilistic Forecasting**
- **What-if Analysis Capabilities**
- **Optimization Capabilities**
- **Recommendations**



Outcome: Better visibility, Early problem detection, Optimal response

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Framework for Digitalization in Oil & Gas Production (II)

1 **Downtime**

↕

Downtime Reduction

2 **Suboptimal Operation**

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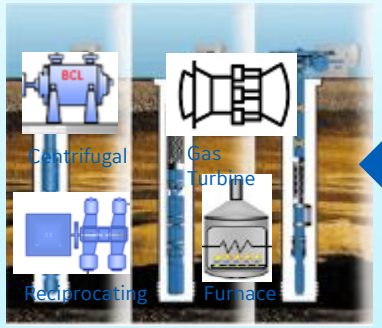
Production Optimization

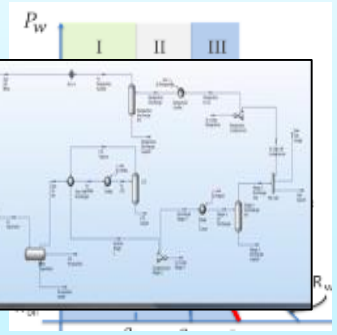
3 **Bottlenecks**

↕

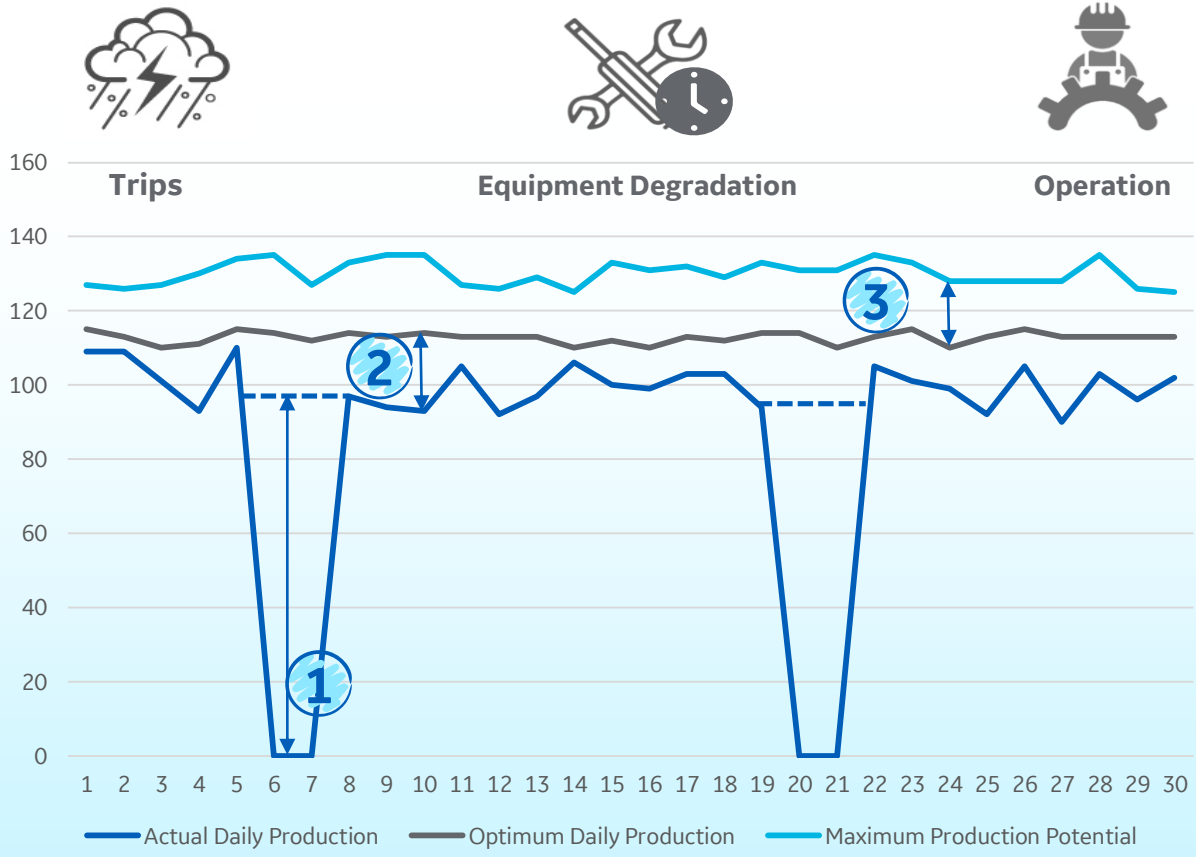
Increase Maximum Production Potential



Equipment



Production System



"70% of unplanned downtime comes from improper operation versus equipment degradation"

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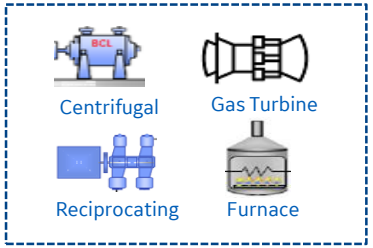
Automation & Control: Combining equipment reliability and process

Key Building Blocks

1 **Asset degradation & Anomaly detection**



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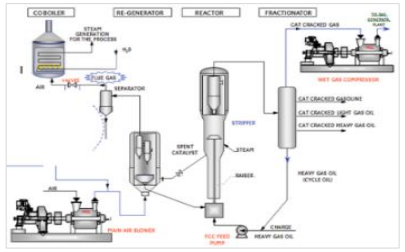
2 **Process Simulations**



3 **People Workflow**

BHGE Applied AI – Analytics Engine | Rapid Query Engine | Data Fabric
Analytics orchestration across OEM, 3rd party , partners and internal development

First principle Models ⟷ Empirical Models

Outcomes

- Increase revenues
- Decrease energy expenses
- Decrease non energy expenses

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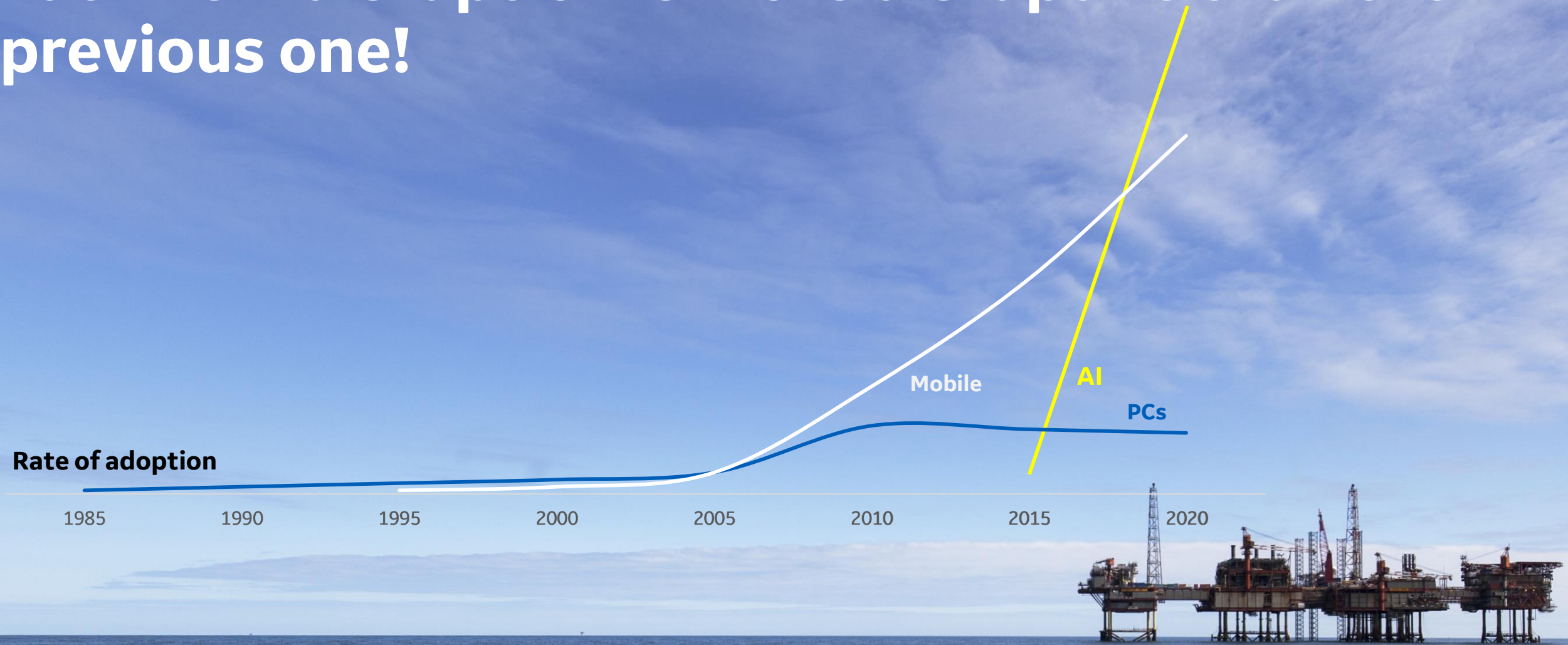
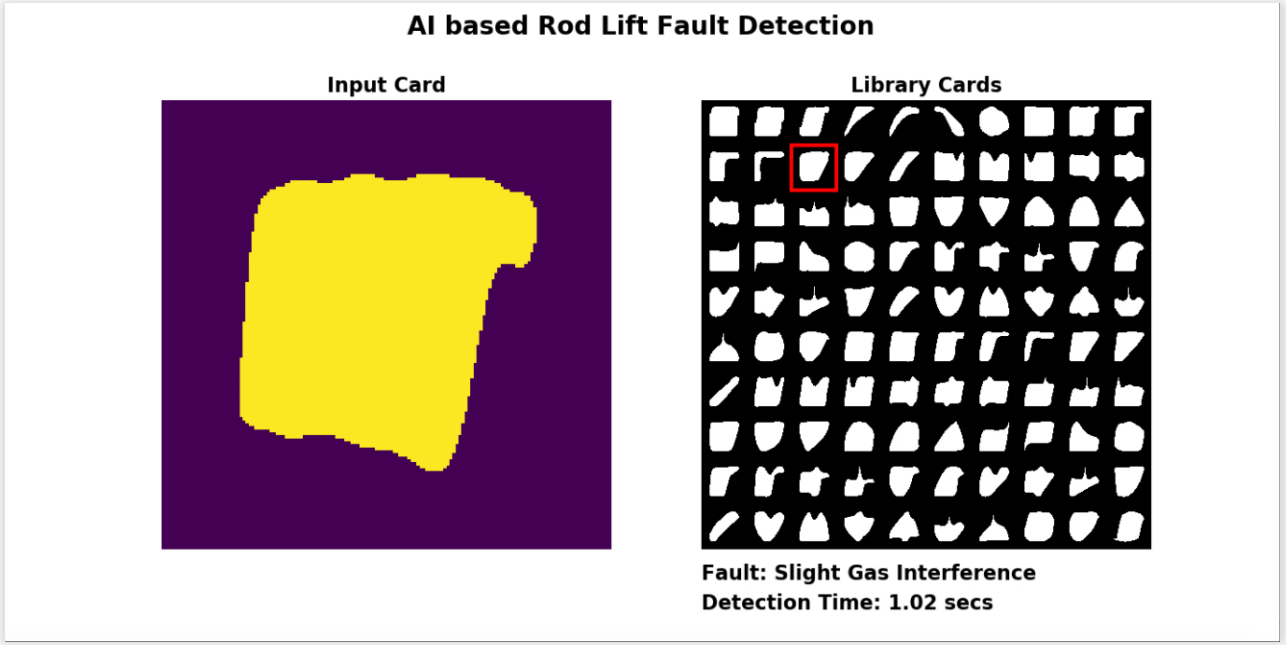
Each new disruption is more disruptive than the previous one!



RLS Dynacard Pattern Matching

- Millisecond level automatic fault identification for known faults
- AI learns from human exert for unknown faults… and packages, distributes “expertise” to all sites instantly



Multi-Well Optimization

Multi-well Optimization subject to cluster constraints

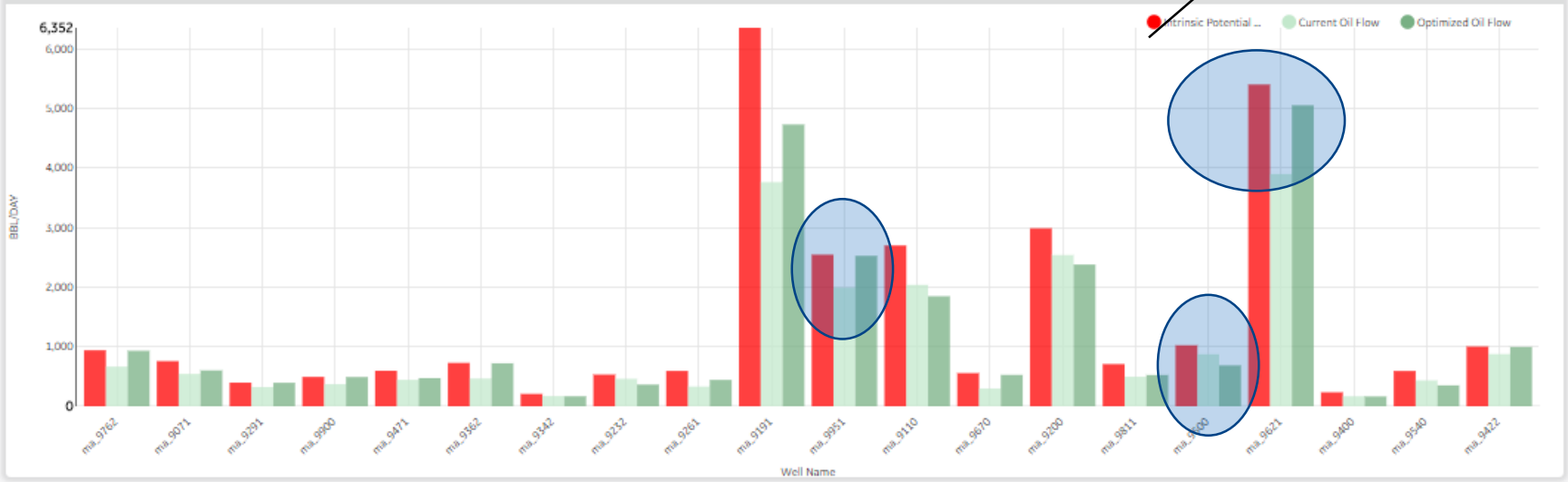
	OIL	WATER	GAS
	BBL/DAY	BBL/DAY	MCFD
ma_9762	931 / 665	637 / 455	0.222 / 0.207
ma_9071	602 / 542	1586 / 1428	0.158 / 0.142
ma_9291	394 / 323	497 / 408	0.064 / 0.062
ma_9900	491 / 371	303 / 229	0.033 / 0.025
ma_9471	472 / 444	1099 / 1034	0.165 / 0.155
ma_9362	722 / 465	732 / 471	0.156 / 0.124
ma_9342	168 / 171	776 / 790	0.057 / 0.057
ma_9232	364 / 460	2127 / 2688	0.073 / 0.092
ma_9261	443 / 330	3940 / 2930	0.032 / 0.024
ma_9191	4730 / 3761	2454 / 1952	2.088 / 1.848

OIL 24369 BBL/DAY (+3230) | WATER 32366 BBL/DAY (-120) | GAS 8.251 MCFD (+0.794) | POWER 2692 HP (-299)

Optimize Cluster

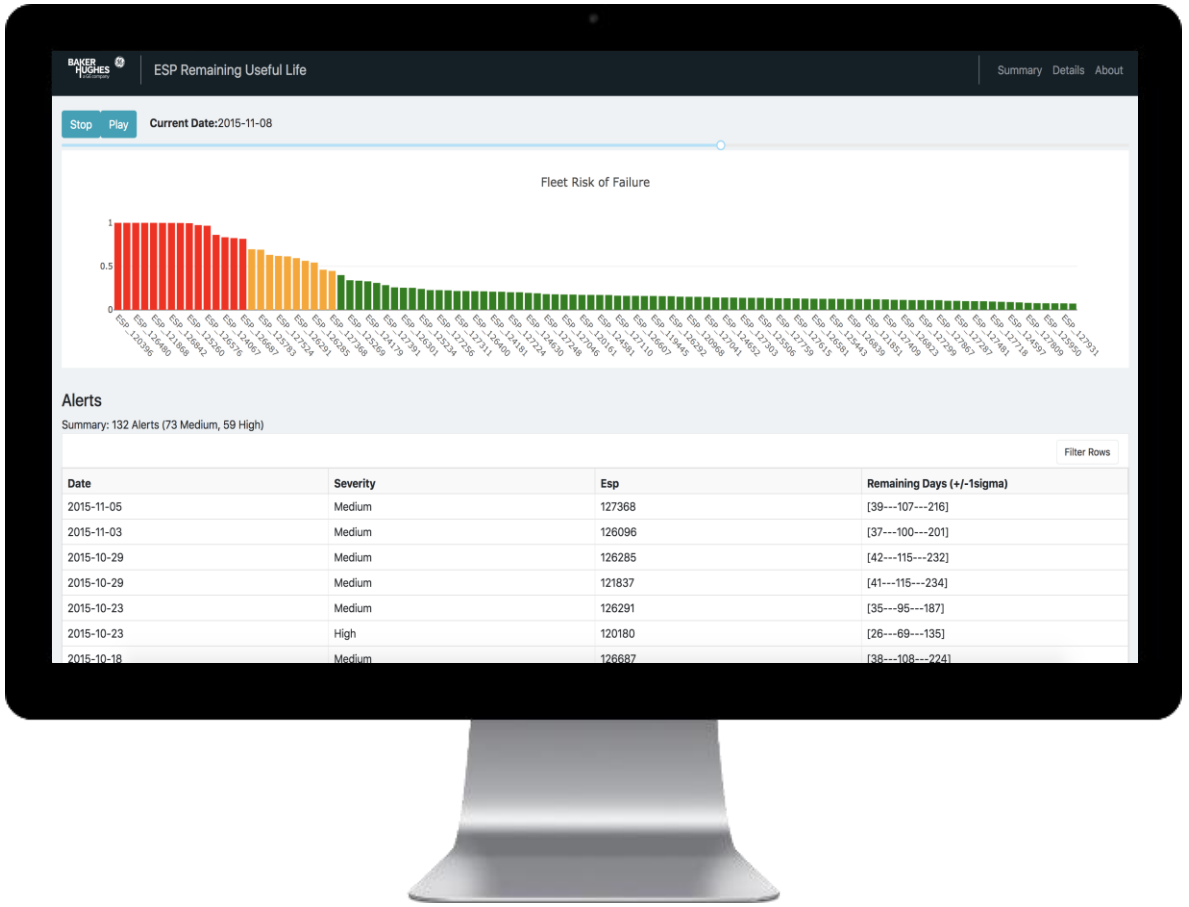
CLUSTER CONSTRAINTS

OPTIMIZED FLOW OF OIL



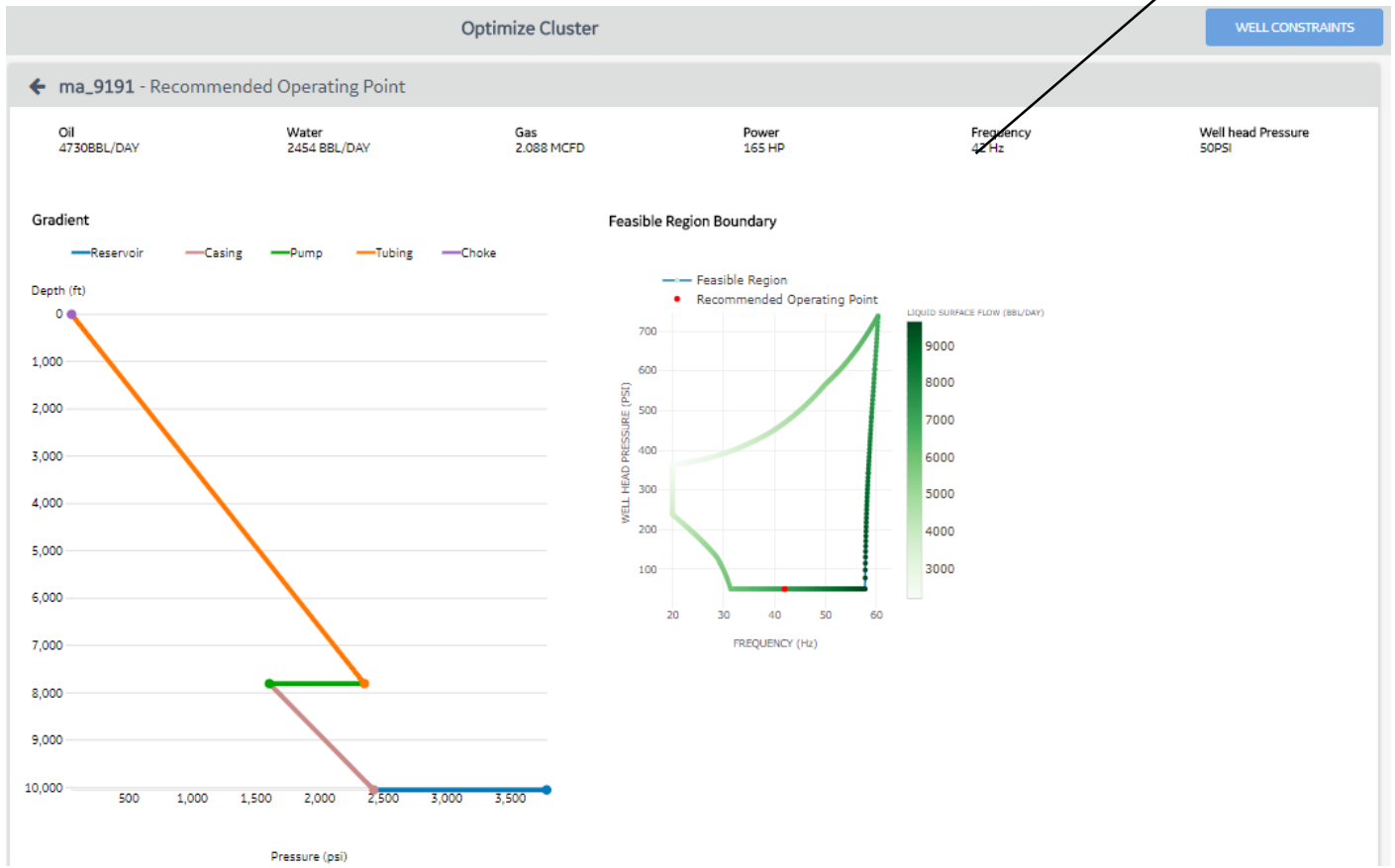
ESP Remaining Useful Life Estimation

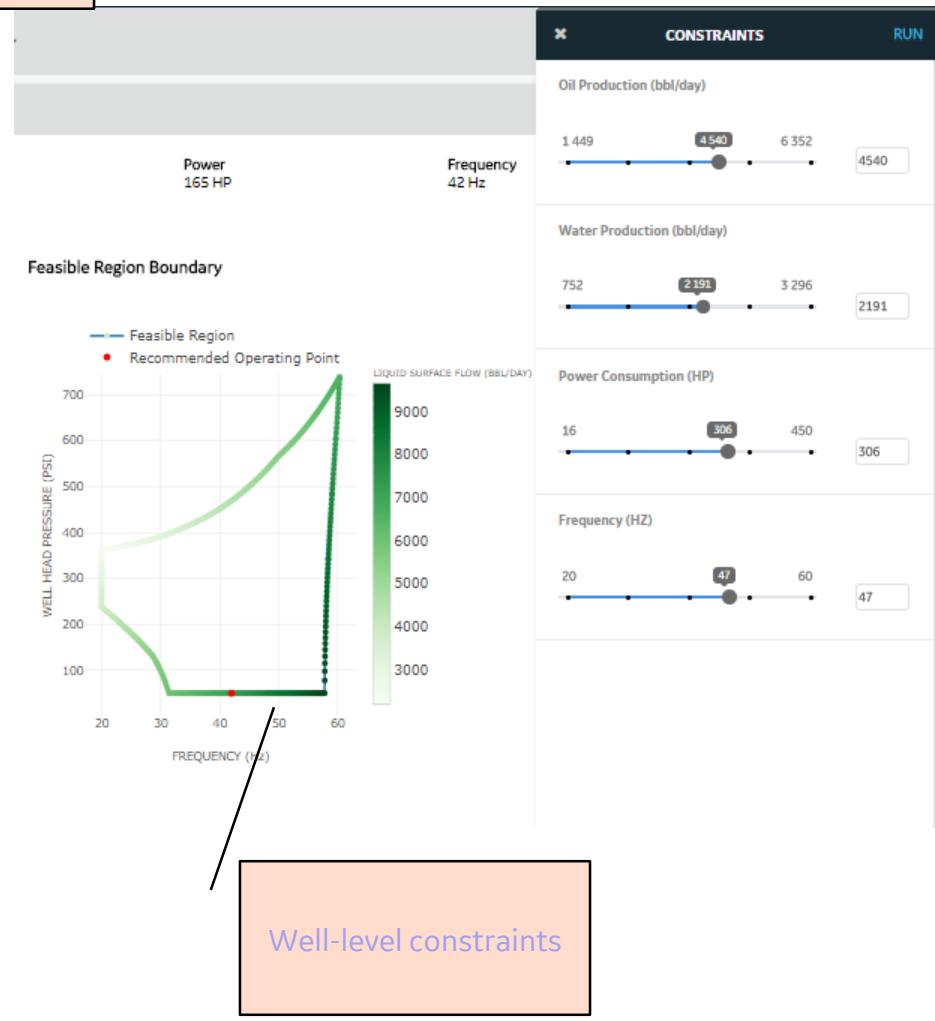
- Upstream Production Optimization has traditionally been constrained by unexpected downtime, often caused by equipment issues
- AI is being used to overcome this limitation, so *equipment health-aware* production optimization is now viable



Multi-Well Optimization

Individual well settings





Well-level constraints

Multi-Well Optimization

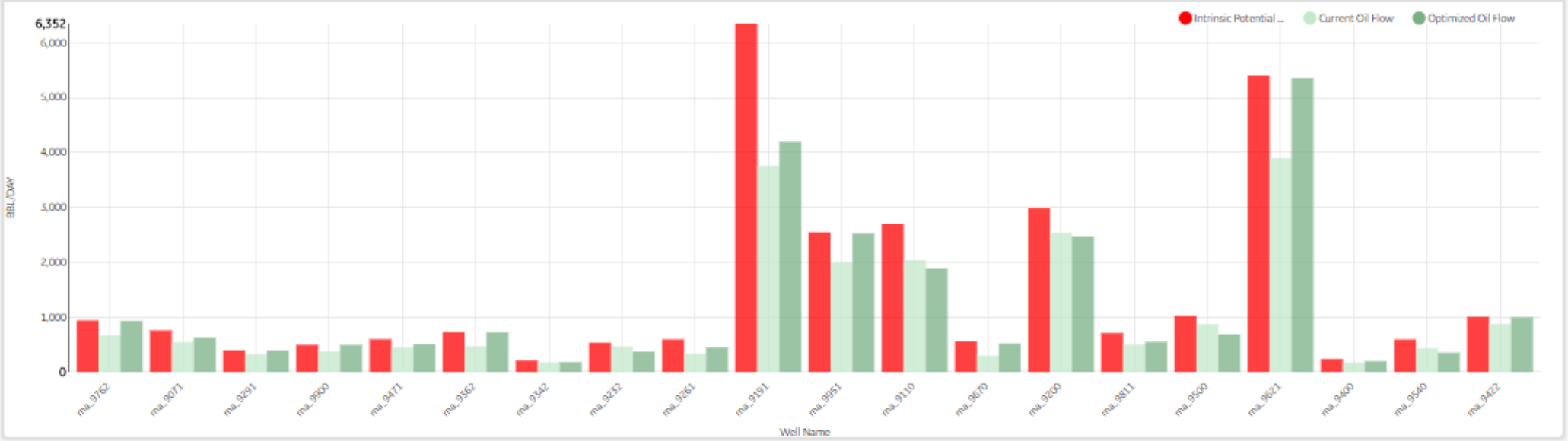
Recalculated optimum

	OIL BBL/DAY	WATER BBL/DAY	GAS MCFD
ma_9762	931 665	637 455	0.222 0.207
ma_9071	627 542	1652 1428	0.164 0.142
ma_9291	394 323	497 408	0.064 0.062
ma_9900	491 371	303 229	0.033 0.025
ma_9471	502 444	1171 1034	0.176 0.155
ma_9362	722 465	732 471	0.156 0.124
ma_9342	176 171	813 790	0.058 0.057
ma_9232	369 460	2153 2688	0.074 0.092
ma_9261	444 330	3949 2930	0.032 0.024
ma_9191	4195 3761	2177 1952	1.966 1.848

Optimize Cluster

CLUSTER CONSTRAINTS

OPTIMIZED FLOW OF OIL



Conclusion

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