QuantumBasel

Center of Competence
for Quantum Computing and AI

Hybrid

Quantum Annealing

Real-time Job Shop Scheduling in Pharma

2025 | Use Case | Optimization with a Hybrid Classical-Quantum Annealing Solution

Pfizer Inc. is one of the world's largest biopharmaceutical companies, operating a complex global network across R&D, manufacturing, and distribution. Its products span critical therapeutic areas like oncology, immunology, and vaccines, requiring precise, multi-stage production under strict quality and regulatory standards. Efficient scheduling is essential to manage this scale and complexity. To explore next-generation planning solutions, Pfizer partnered with D-Wave and QuantumBasel to conduct a Proof of Technology (PoT) using a hybrid quantum-classical annealing approach. The goal: improve production scheduling at Pfizer's Freiburg plant compared to existing and newly optimized classical methods.

Pfizer | QuantumBasel | D-Wave The Quantum Computing Company™

THE CHALLENGE

Pfizer's Freiburg site faces **significant complexity** in its production planning. The plant operates under conditions of **high resource utilisation** and **interdependent, multi-stage manufacturing processes** operated in product campaigns. In addition, the **schedule** needs to be **flexible** and **quickly adaptable** to any **unforeseen events or changes** in the production process.

Last-minute schedule changes require significant manual effort and expertise, making it **hard to consistently optimize for delivery, output, and cost**. The result is a need for more agile, intelligent scheduling solutions that can reliably handle these dynamic conditions and enhancing the utilization rate of the machines.

≈ ⅔
makespan reduction in timeframe analyzed

≈ ⅓
less **constraint violations**

100%
reduction of **critical issues***

*no machine overlaps, priority conflicts, or closing time violations observed

PROJECT GOAL

In collaboration with QuantumBasel and D-Wave, Pfizer initiated a **Proof of Technology (PoT) project** to explore advanced methods for job shop scheduling. The primary objective was to **evaluate the effectiveness of hybrid quantum-classical annealing methods** compared to the current production solution as well as to compare against a newly designed classical high-performance computing (HPC) solution in **optimising a six-week production campaign at the Freiburg site**. The project aimed to **improve critical performance metrics** - such as makespan (ie the effective duration of the schedule, from first assigned task to completion of the final task), tardiness (number of days beyond deadlines), number of late jobs and constraint violations - while **assessing the potential for scalable implementation** across Pfizer's global manufacturing network.

This initiative has brought together local and global stakeholders to **test the viability of next-generation computing technologies** in a **real-world** pharmaceutical **manufacturing environment**.

METHODOLOGY

The team has used a **representative dataset covering a six-week production window**, **focusing on all jobs and subtasks scheduled within that period**. The classical optimisation approach used GPU-based HPC systems and state-of-the-art **classical optimization solvers**, while the hybrid quantum method has been performed using the latest **D-Wave's hybrid non-linear quantum annealing solver**, designed specifically for complex optimisation tasks.

The scheduling model incorporated a variety of operational constraints, including machine availability, job priority, operator scheduling, and adaptation to real-time disturbances. **Key Performance Indicators (KPIs) were defined to measure the effectiveness of the model**, as presented earlier: total makespan, number of late jobs, average tardiness, and constraint violations. All KPIs were given equal weight in the optimisation process.

Although this first PoT has used a relatively small dataset, it has provided a **strong foundation**. **Future phases are planned to include larger, more complex data sets** from additional production sites to test broader scalability and adaptability.

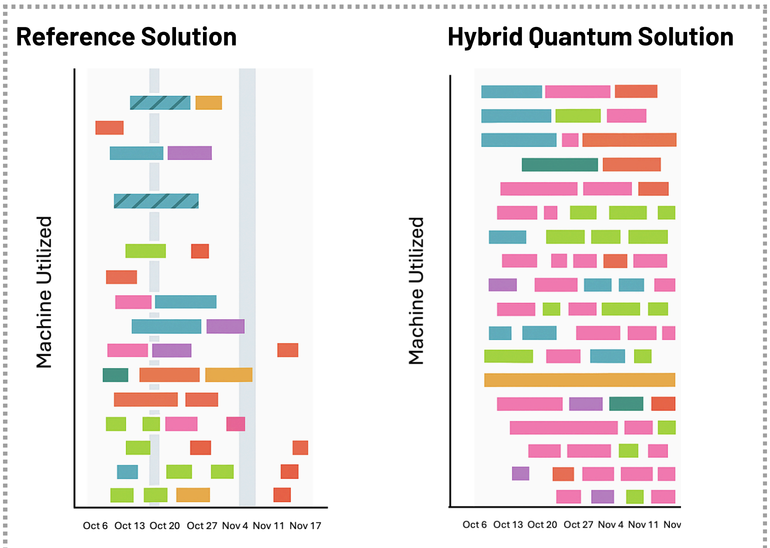
Hybrid Optimization Tested

Real Constraints Modeled

Scalable Path Ahead

RESULTS

The results have shown **clear advantages for both classical and quantum optimisation methods - especially the latter. Total makespan has been reduced by ≈ ⅔** compared to the reference solution, leading to a significant improvement in overall production efficiency. **Constraint violations have been reduced by ≈ ⅓** and **key problems** such as machine overlaps, priority conflicts and closing time violations **have been completely eliminated**. The number of late jobs and average tardiness have also been significantly reduced.



Pict. 2: Production Planning Solutions Comparison Visualization (symbolic AI-generated visualization)

Comparing classical and hybrid quantum optimization solutions, the **hybrid quantum solution has slightly outperformed** the classical HPC model in terms of overall effectiveness. While the classical method has delivered strong results on this dataset, the hybrid quantum solution has been able to deliver slightly better results and is likely to be more scalable to more complex constraints and larger problems.

“This collaboration with QuantumBasel and D-Wave has allowed us to explore the real potential of quantum technologies in a complex, high-stakes production environment. The results we’ve seen at our Freiburg site demonstrate that hybrid quantum approaches can meaningfully enhance scheduling performance and efficiencies, and support a more agile manufacturing process. As we look ahead, we see great promise in further scaling these methods.”

Pembe Gül Bilir, Project Engineer Innovation, Pfizer Freiburg

- **Product makespan was reduced by ≈ ⅔**, enabling faster completion of all scheduled jobs.
- **Constraint violations dropped by ≈ ⅓**, resulting in smoother and more compliant scheduling.
- **Critical issues were fully eliminated**, with no machine overlaps, priority conflicts, or closing time violations observed.
- There was a **significant decrease in late jobs and average tardiness**, leading to improved on-time delivery performance.

BUSINESS IMPACT

Optimised schedules have the potential to **transform the way Pfizer manages production planning**. Faster, more flexible scheduling supports faster ramp-ups, **adapts more easily to unforeseen events and changes in the production process** and **reduces the time required for manual adjustments**. By improving resource efficiency, the new schedules **could potentially increase overall output and provide significant potential to use machine downtime more effectively—for example, for preventive maintenance**. This may lead to **cost savings** through **reduced energy consumption** and **improved capacity planning**. Importantly, the hybrid quantum approach is **highly scalable and particularly well suited to larger data sets and more complex manufacturing scenarios**. To gain further insights into the method's global business impact, the next step would be to test it on larger datasets.

"While there are many theoretical proofs of concept for quantum annealing, real-world applications remain rare. This project with Pfizer is one of the latter, and a key example of how hybrid quantum-classical methods are already delivering real business value in complex areas such as manufacturing planning."

Dr. Julien Baglio, QuantumBasel, Quantum Algorithms Researcher

The best performance within the PoT was achieved with the quantum optimised solution, followed by the classical optimisation approach.

With increasing complexity and data set, an even greater advantage of quantum over classical is expected.

	GPU Optimized Solution vs. Reference	Quantum Optimized Solution vs. Reference
	Improved by:	Improved by:
Makespan [days]	≈ 1/2	≈ 2/3
N° of late jobs [-]	≈ 1/4	≈ 1/3
Average tardiness [days]	≈ 1/5	≈ 1/4

Pict. 3: Performance Comparison of Each Method

NEXT STEPS

Following the success of this initial PoT, **Pfizer plans to expand the study to larger datasets and further refine the models**. This effort will include expanded testing, integration with Pfizer's existing systems, and an evaluation of the long-term business impact in additional manufacturing environments.

Read more under https://healthcarehub.pfizer.de/quantum-annealing-proof-technology-pfizer-freiburg-explores-new-methods-production-planning

For further details, don't hesitate to contact us!