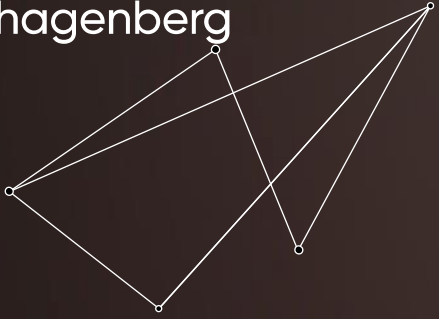


```
scch {  
  software  
  competence  
  center  
  hagenberg  
}
```



Stefan Hillmich
stefan.hillmich@scch.at



Mathias Gartner
mathias.gartner@scch.at



Rudolf Ramler
rudolf.ramler@scch.at

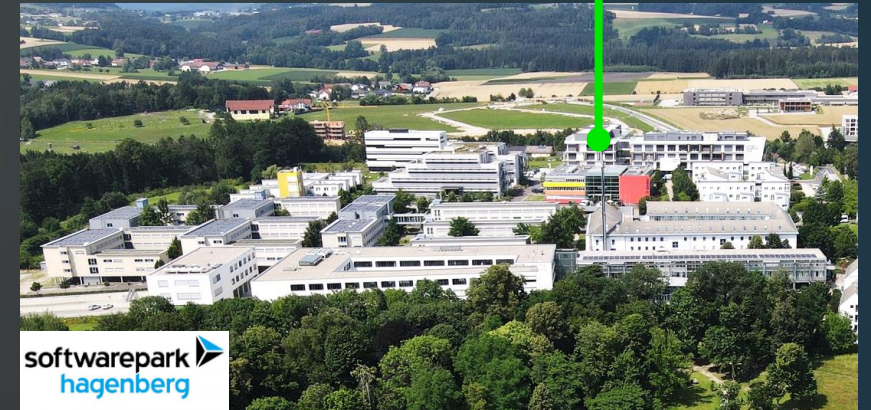
Getting QuantumReady

A Framework for Exploiting Quantum Computing
in SMEs

Software Competence Center Hagenberg

scch {}

- Non-profit Ltd. research organization for Data Science & Software Science
- Founded by Johannes Kepler University Linz in 1999
- Owner: State of Upper Austria, Johannes Kepler University, association of company partners
- ~130 employees (>160 including partners)
- COMET competence center (FFG funded)



The QuantumReady Project

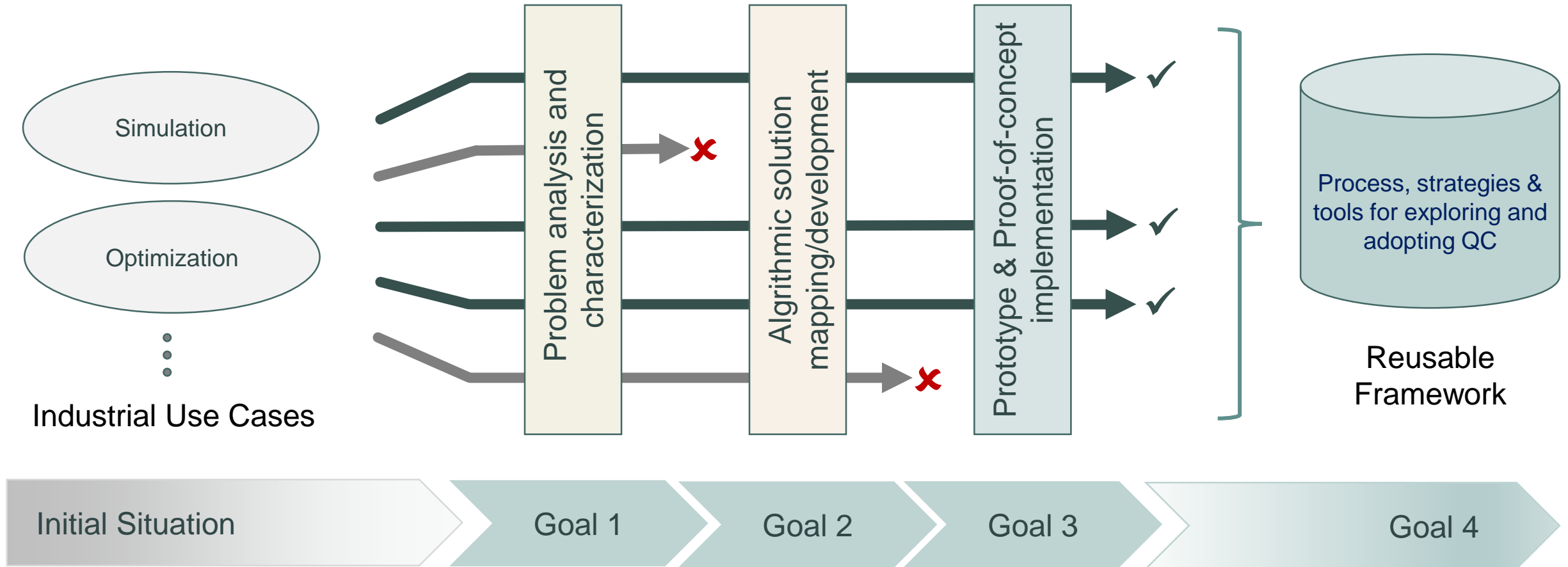
scch { }

- Exploring and Realizing the Advantages of Quantum Computing for Early Adopters
- Quantum Computing for the Austrian Industry
- Funded through Quantum Austria managed by FFG
- R&D Project
- Prototyping for Industrial Solutions

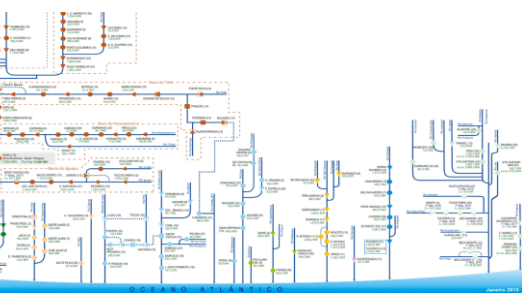
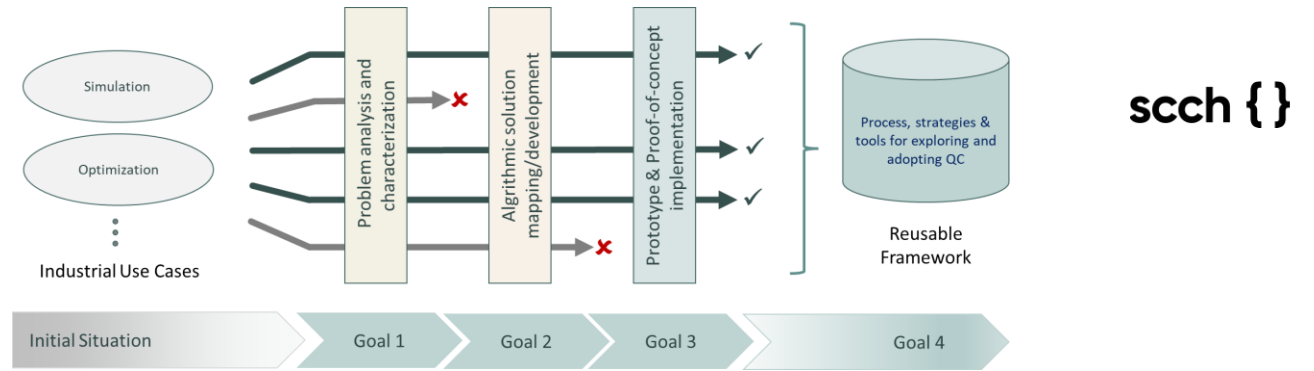


Getting QuantumReady

scch { }

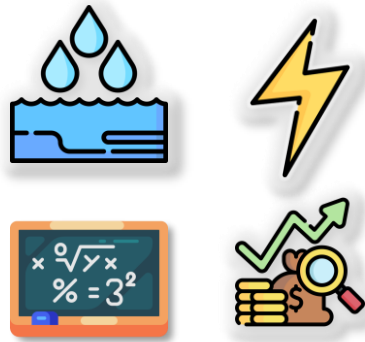


Example Use Cases



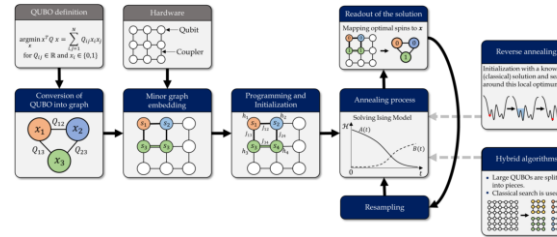
Initial Situation

Network of Hydropower Plants in Brazil



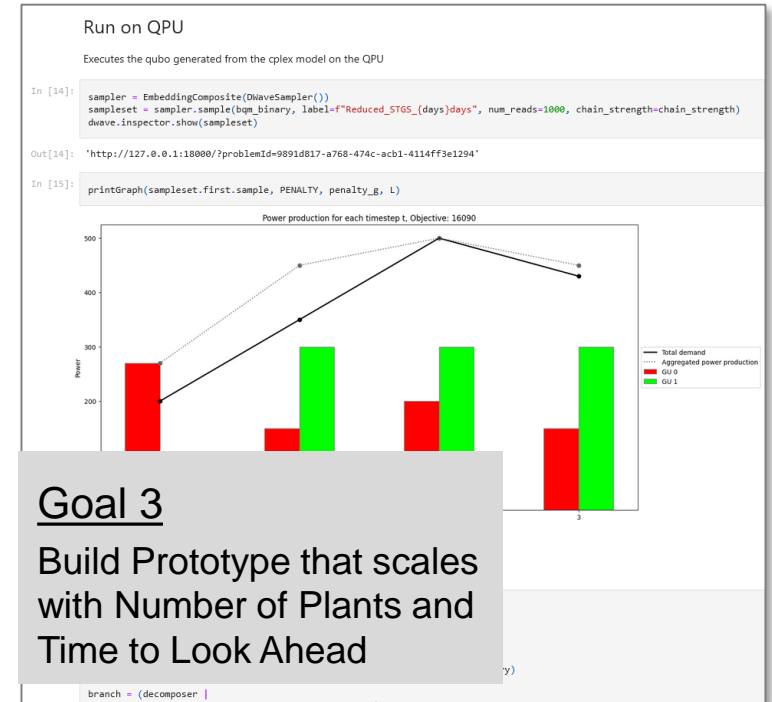
Goal 1

Model Energy Production with Forecasts and Revenue



Goal 2

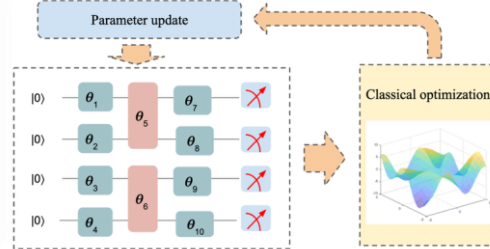
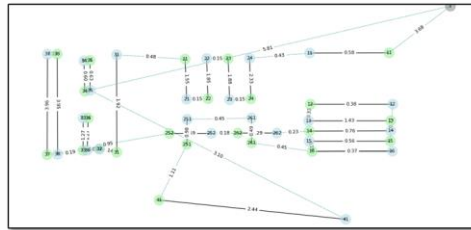
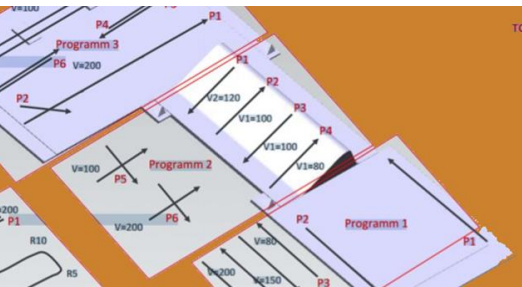
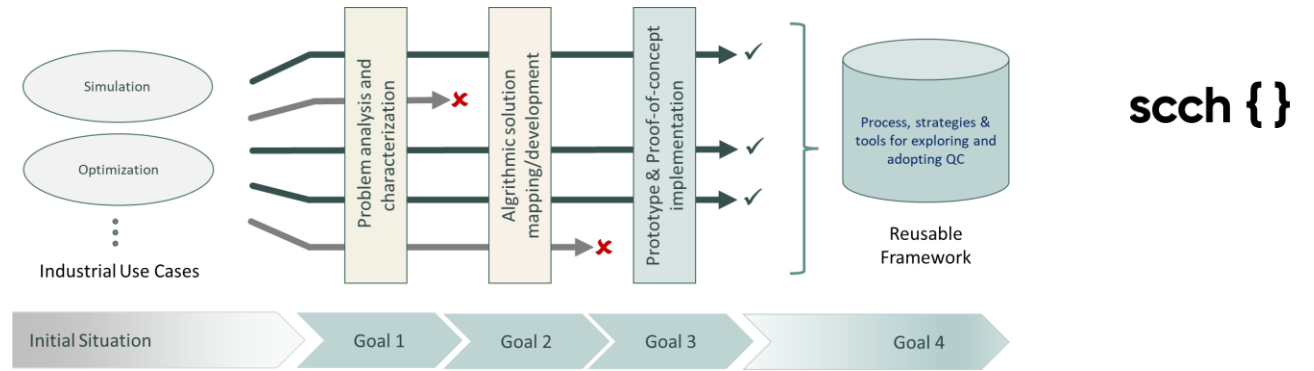
Map to QUBO for Evaluation on Quantum Annealer



Goal 3

Build Prototype that scales with Number of Plants and Time to Look Ahead

Example Use Cases



```

first_cut = set(iname for i, iname in enumerate(ess.node_list) if res_bits[i] == 1)
fig, ax = plt.subplots(figsize=(11, 9))
raw_cut_size = nx.cut_size(g_beads, S=first_cut, weight='weight')
clean_cut_size = raw_cut_size - ROBOT_SEP_PENALTY if len(first_cut & ("R1", "R2")) == 1 else raw_cut_size
ax.set_title(f"raw_cutsize={raw_cut_size:.3f} / clean_cutsize={clean_cut_size:.3f}\n(Max cutsize from brute force: {max_cut_size:.3f})")
pos = nx.get_node_attributes(g_beads, 'pos')
edgelist[(u, v) for u, v, color in g_beads.edges(data='color') if color != "white"]
nx.draw_networkx_nodes(g_beads, pos=pos, ax=ax, alpha=0.5,
edgecolors=[("black" if u in first_cut else "white" for u in g_beads.nodes),
node_color=[("lightgreen" if u in first_cut else "lightblue" for u in g_beads.nodes)])
nx.draw_networkx_labels(g_beads, pos=pos, ax=ax,
edgecolor="black",
style="solid"
)
plt.draw()
Number of Qubits: 8
ansatz isa ops: OrderedDict({'rzz': 54, 'rx': 12, 'h': 6, 'x': 1}) ==> 73
hamiltonian isa paulis: 27
parameters: ['beta[0]', 'beta[1]', 'gamma[0]', 'gamma[1]']
Initial parameters: [3.82045746 1.91022873 2.13922522 1.06961261]
Minimize
67 --> -7.9962624
167 --> -13.6187731
267 --> -14.0177266
326 --> -14.0178624
message: The lower bound for the trust-region radius has been reached
status: True
fun: -14.017862424004429
x: [ 3.726e+00  2.424e+00  2.098e+00  9.995e-01]
    
```

Initial Situation

Process a Number of Given Items as Fast as Possible

Goal 1

Abstract the Problem to a Graph, Retaining the Important Information

Goal 2

Construct Target Function and Apply QAOA

Goal 3

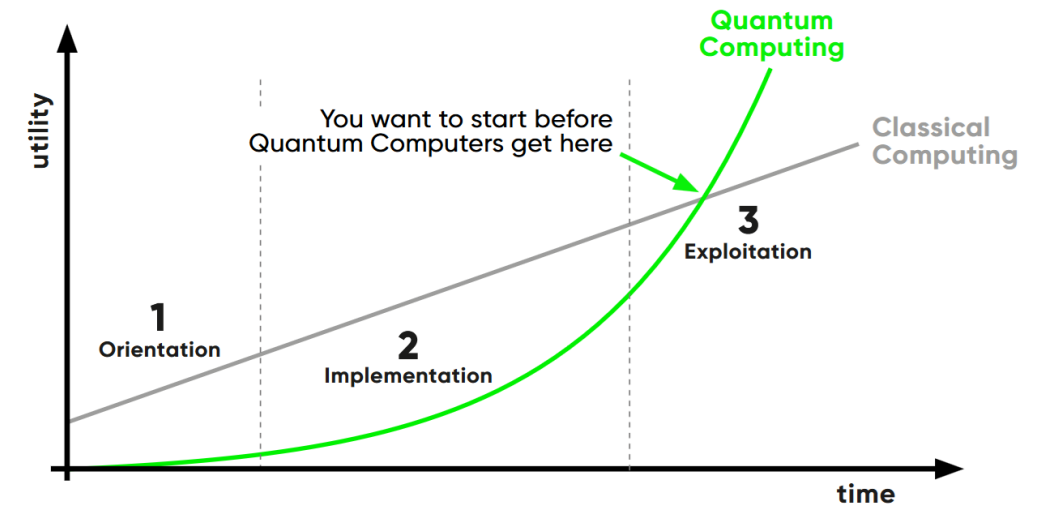
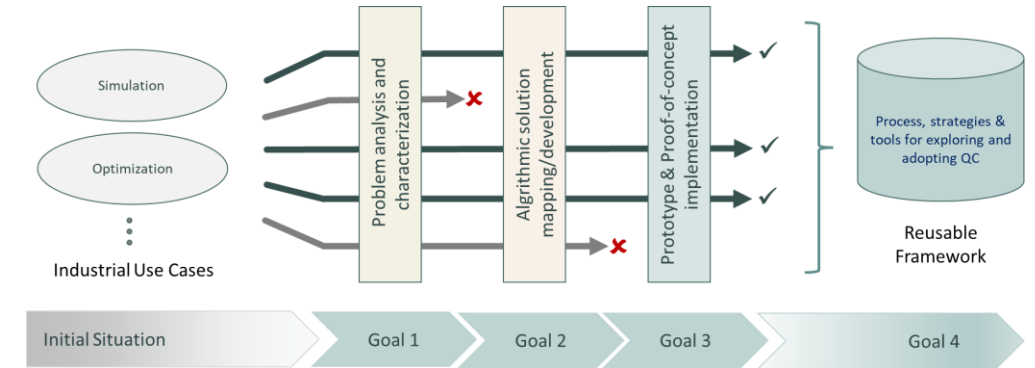
Build a Prototype that Scales with the number of Items and Workers



Conclusion – Reusable Framework

scch { }

- Goal of evaluating 10+ use cases
 - Logistic, Energy, Finance, ...
- Evidence enables a more efficient approach
 - Streamlined Process
 - Tested Strategies
 - Continuously improved Tools
- Results drive the decision on the next steps
 - Identifying suitable problems
 - Estimating a timeline to quantum utility
 - Getting an idea what quantum is about



Conclusion – Reusable Framework

- Goal of evaluating 10+ use cases
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Quantum Algorithm Engineering (QAE)
 Bridging the Gap to Industrial Applications
 Stefan Hillmich, Sonja Bruckner, Mathias Gartner, Rudolf Ramler, Robert Wille
 (stefan.hillmich, sonja.bruckner, mathias.gartner, rudolf.ramler, robert.wille@scch.at)

“Our vision for QAE is to bridge the gap between the applications and the low-level quantum software ecosystem.”

Quantum Combinatorial Optimization

- Identify Problem Classes
- Identify Quantum Approaches
- Stochastic Optimization

Expected results:

- Categorization of problem classes and applicability
- Survey reports of QAOA algorithms and their results
- Trade-off between classical, semi-classical and quantum quality
- Integration into test hardware and optimization-criteria tools

Quantum Machine Learning

- Shallow Theories
- Classical Theories
- Full Quantum QML

Expected results:

- Theoretical results on Classical Data/Quantum Algorithms
- Applications for Quantum Data/Classical Algorithms
- Resource requirements on quantum hardware for data acquisition
- Fully quantum-based learning

Hybrid Quantum Computing

- Hardware Language
- Classical Backend/Control
- Performance Models

Expected results:

- Hybrid quantum-classical workflow architecture language
- Hybrid benchmarking suite
- Performance models for quantum hardware
- Resource management for hybrid quantum-classical workflows

Quantum Software Environment

- Modeling language
- Block-level Engineering
- Synthesis Planner

Expected results:

- Hybrid quantum modeling language
- Block-level algorithm engineering method
- Hybrid cost-function quantification language
- Learning-based synthesis engine
- Integration of the developed methods into larger software stacks

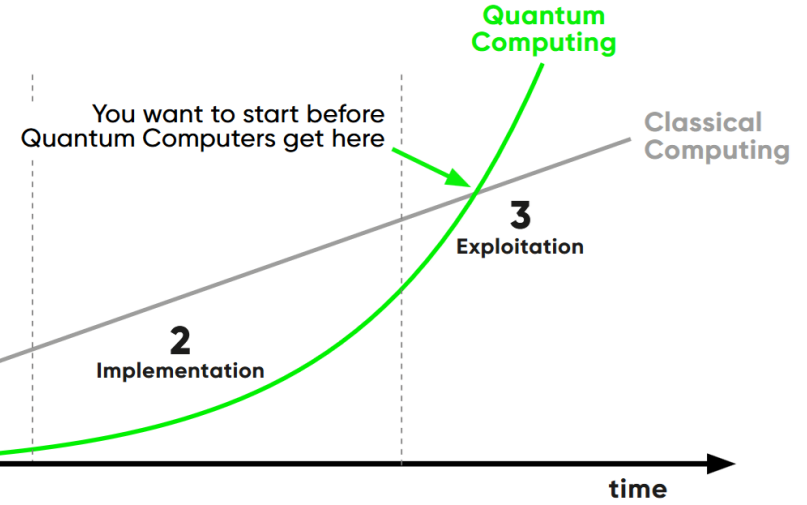
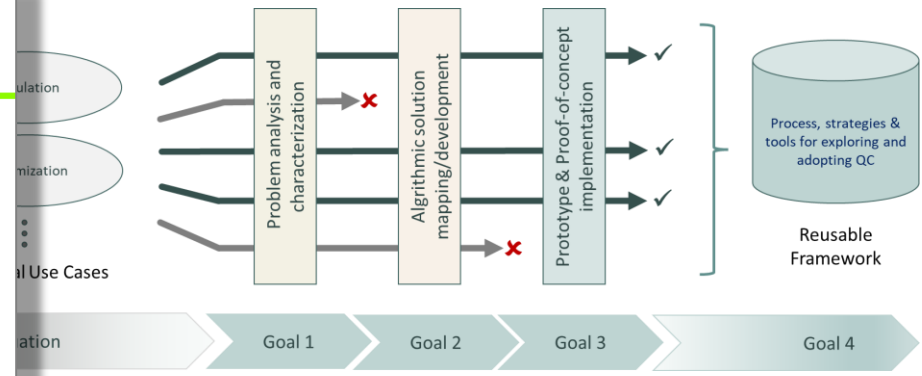
Introduction

Quantum computing is rapidly advancing, in both hardware and software development. However, there is a significant gap between the potential of quantum computing and its practical applications. QAE aims to bridge this gap by connecting industry with the quantum ecosystem and developing tools to facilitate the use of quantum computing in industrial settings. This project focuses on the development of a reusable framework for quantum algorithm engineering, which will enable the efficient, maintainable, and reusable software development of quantum algorithms for industrial applications.

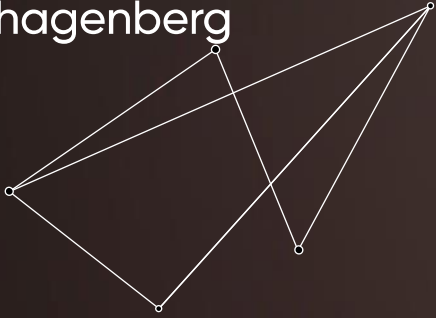
Key Goals

- G1: Demonstrate the (non-)relevance of quantum computing for relevant use cases.
- G2: Establish software engineering for quantum computing to enable efficient, maintainable, and reusable software development.
- G3: Make quantum computing more accessible for industry applications.

See our poster for a new project.



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Dr. Stefan Hillmich
Senior Researcher
+43 50 343 890
stefan.hillmich@scch.at

Prof. Dr. Robert Wille
CSO
+43 50 343 881
robert.wille@scch.at

Mag. Rudolf Ramler
Research Manager Software Science
+43 50 343 872
rudolf.ramler@scch.at

SCCH ist eine Initiative der



SCCH befindet sich im



Dr. Flavio Ferrarotti
Key Researcher
+43 50 343 869
flavio.ferrarotti@scch.at

Sonja Bruckner, MSc
Researcher
+43 50 343 855
sonja.bruckner@scch.at

Dr. Mathias Gartner
Researcher
+43 50 343 919
mathias.gartner@scch.at

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