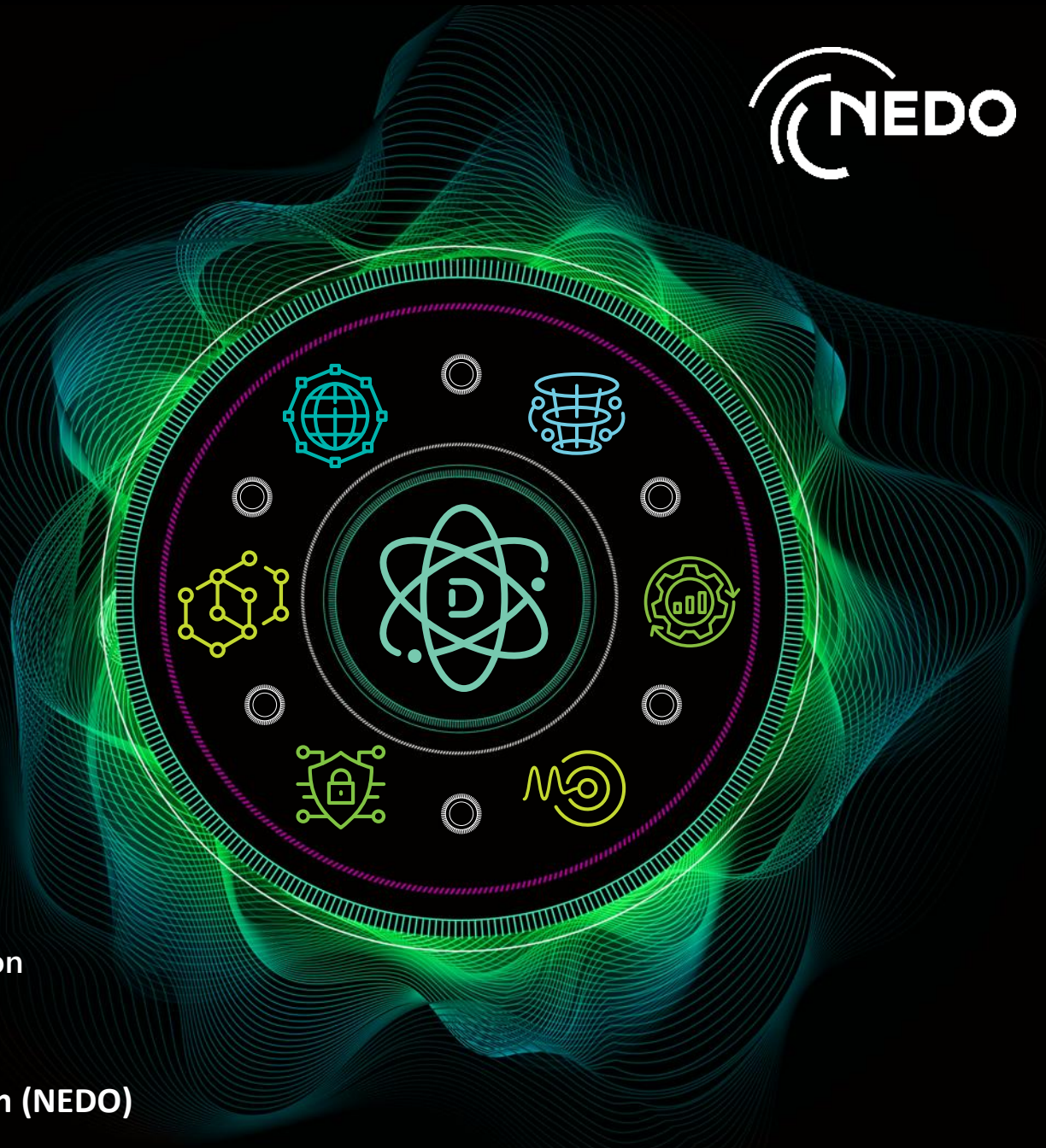
Quantum Computing Use Cases

Innovation in the manufacturing process of recyclable materials



Promotion of SDGs with Quantum Technology

©2026 Q-STAR, Quantum STrategic industry Alliance for Revolution

New Energy and Industrial Technology Development Organization (NEDO)

循環可能材料の製造プロセス革新
Innovation in the manufacturing process of recyclable materials



ユースケース概要 **Use Case Overview**	製造プロセスの革新により、材料取得と廃棄物排出が環境に与える負荷を低減 Reduce the environmental impact of procurement and disposal through manufacturing innovation.
解決できる課題と効果 **Issues to be addressed and their effects**	リサイクル・炭素固定技術により、製造業のカーボンニュートラルを実現 Achieving carbon neutrality in the manufacturing industry through recycling and carbon fixation technologies.
量子技術の貢献 **Contributions of quantum technology**	量子化学計算により、最適出発材料や合成・製造プロセスの計算を高速化 Accelerating the calculations for optimal starting materials and synthesis/manufacturing processes.

実現予想時期 **Expected realization period**	(Year)2035～2040
産業分類 **Industry classification**	製造(素材) Manufacturing(materials)
関連するQRAMI階層 **Related QRAMI layers**	機能層 Functional layer
関連する量子技術 **Related quantum technologies**	量子材料、量子コンピュータ Quantum Materials、Quantum Computer

新規性 **Novelty**	一部の新要素 Some new elements
達成難易度 **Difficulty of achievement**	容易 Easy
社会貢献度 **Social contribution level**	特定の業種に貢献 Contributions to specific industries
市場規模 **Market size**	10兆円～ 10T¥～

Detail

Innovation in the manufacturing process of recyclable materials

- Reduce environmental effects without sacrificing material wealth through process simulation and innovation and the implementation of recyclable-material design



100%
Reduction in actual CO_2 emissions in manufacturing

Innovating manufacturing processes and using recycling and carbon-fixation technology will achieve carbon neutrality in manufacturing, balance CO_2 emissions and absorption, and reduce emissions to “virtually zero.”

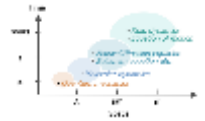
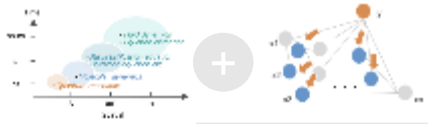
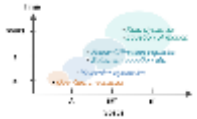
Potential contribution of computational technology		Feasible ultimate world
Process simulation	Process innovation	It is possible to maximize the efficiency of raw materials, energy, and labor and to carry out production activities without waste.
Proposing optimal reaction processes and operations	Process innovation	Innovation in materials and processing processes will be accelerated in a manner that supports technological innovation in each field.
Developing recycled materials	Implementing recyclable-material design	The burden on the environment from obtaining raw materials and discharging waste will be reduced, and the climate and biosphere will be maintained.
Scaling-up and reducing costs of recycling technology	Implementing recyclable-material design	Resources will be available forever without decreasing in quantity.
Improving manufacturing technology using renewable natural resources	Implementing recyclable-material design	
Proposing optimization of materials and synthesis processes for carbon-fixation technology	Implementing recyclable-material design	

Supportable SDG goals



Roadmap

Innovation in the manufacturing process of recyclable materials

Process		Necessary R&D and business development	Quantum-computer scope of contribution and future development issues	
Process simulation and process innovation	Establishing a complete model that describes the process	■ Modeling of each process. Basically, it should be theoretically possible to describe a process as the diffusion of heat and temperature and the chemical reaction at each reaction site.		■ Accelerating quantum chemical calculations ■ Developing algorithms to solve MD equations quickly
	Proposing optimal reaction processes and optimal operation	■ Proposing optimal reaction processes on the basis of factors such as required supply volume, available workforce, and material prices and proposing optimal daily operations for those processes on the basis of daily fluctuation factors such as temperature, demand, and customer requests. ■ Establishing a method for accessing quantum computers from multiple edges Developing and providing solution packages ranging from proposing optimal reaction processes to proposing daily operations	Solving theoretical models and optimization calculations 	■ Accelerating quantum chemical calculations ■ Developing algorithms to solve MD equations quickly ■ Accelerating the search for optimal solutions ■ Real-time and large-scale execution of established mathematical models
Implementing recyclable-material design	Material design including recyclability	■ Developing new materials with high recyclability (e.g., easy-to-recycle advanced composite materials) ■ Scaling-up and reducing cost of recycling technology → Quantum chemistry and molecular-dynamics calculations are used to speed up calculations concerning optimal starting materials and synthesis/manufacturing processes according to required physical property values.		■ Accelerating quantum chemical calculations ■ Developing algorithms to solve MD equations quickly
	Improving manufacturing technology by using renewable natural resources	■ Developing technology for manufacturing materials by using renewable raw materials (e.g., manufacturing plastics using biomass and constructing high-rise buildings using wood) ■ Sensing the properties of renewable natural resources and simulating their optimal use (e.g., measuring fiber density of wood to select the best building materials) ■ Standardizing renewable natural resources (e.g., controlling the amount of sunlight and rainfall for wood to standardize its properties and make it easier to handle as a material)	-	■ None in particular
	Establishing carbon-fixation technology	■ Developing carbon-fixation technology and resource-recovery technology (CCS, etc.), catalyst development, artificial photosynthesis, methanation, and other new materials and synthesis processes → Quantum chemistry and molecular-dynamics calculations are used to speed up calculations concerning optimal starting materials and synthesis/manufacturing processes according to required physical property values.		■ Accelerating quantum chemical calculations ■ Developing algorithms to solve MD equations quickly

Roadmap

Innovation in the manufacturing process of recyclable materials

Process		Necessary steps	Items related to quantum computers	2024	2025-2030	2030-2040	Beyond 2040
Process simulation and process innovation	Establishing a complete model that describes the process	■ Collecting and analyzing existing models					
		■ Accelerating quantum chemical calculations	■				
		■ Develop algorithms to solve molecular dynamics equations at high speed	■				
		■ Refining models that reproduce process reactions through quantum chemical calculations	■				
	Proposing optimal reaction processes and optimal operation	■ Accelerating quantum chemical calculations	■				
		■ Develop algorithms to solve molecular dynamics equations at high speed	■				
		■ Accelerating the search for optimal solutions	■				
		■ Establishing quantum algorithms for proposing optimal processes and operations	■				
		■ Establishing process and operation control technology					
		■ Real-time and large-scale execution of established mathematical models	■				
Implementing recyclable-material design	Material design including recyclability	■ Accelerating quantum chemical calculations	■				
		■ Develop algorithms to solve molecular dynamics equations at high speed	■				
		■ Establishing quantum algorithms for material development with recyclability as a necessary physical property	■				
		■ Establishing quantum algorithms for optimizing materials and processes to scale up and reduce costs of recycling technologies	■				
		■ Establishing algorithms for predicting the effect of reducing environmental effects due to introduction of technologies	■				
		■ Considering approaches for disseminating technology (legal regulations, monetary incentives, etc.)					
		■ Establishing technology for making products or parts out of a single material and simplifying sorting for each part					
	Improving manufacturing technology by using renewable natural resources	■ Establishing technology for optimizing material structures using renewable raw materials (biomass, wood, etc.)					
		■ Establishing technology for sensing the properties of renewable natural resources					
		■ Establishing technology for optimizing the use of renewable raw materials					
		■ Establishing standardization technology for renewable natural resources (e.g., pursuing ease of handling as a component rather than standardizing wood properties)					
	Establishing carbon-fixation technology	■ Accelerating quantum chemical calculations	■				
		■ Develop algorithms to solve molecular dynamics equations at high speed	■				
		■ Establishing quantum algorithms for optimizing materials and processes in carbon-fixation and resource-recovery technology	■				

More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)

This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the “Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers ”.