Japanese government energy transition priorities* and how universities can make contributions to these

*Strategic Energy Plan by Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry, JAPAN

Japan's Energy Policy

Points of Progress in the past decade after the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

- Since we experienced the Great East Japan Earthquake in 2011, including the accident at TEPCO's Fukushima Daiichi Nuclear Power Station, the starting point of our energy policy is to take to heart the experiences, reflections, and lessons learned from the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant.

- The government, which has promoted an energy policy based on nuclear power, has a responsibility to do its utmost for the reconstruction and revitalization of Fukushima. As we continue to utilize nuclear energy, we must never forget, even for a moment, the regret of having succumbed to the 'safety myth' and our failure to prevent the tragic events that occurred.

- The government will lead the decommissioning of the Fukushima Daiichi Nuclear Power Plant, with the goal of completing decommissioning by 2041-2051. We will bring together expertise from Japan and other countries and work with unwavering determination.

- The reconstruction of businesses and livelihoods, along with the creation of new industries under the Fukushima Innovation Coast Concept, will be pursued in tandem, like two wheels of a cart. To realize the Fukushima New Energy Society Concept, we will work to further expand the introduction of renewable energy and hydrogen as the two pillars of the concept, as well as to promote their implementation throughout society.

- Given Japan's experience with the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant, we will place the highest priority on nuclear safety and aim to reduce dependence on nuclear power as much as possible. At the same time, we will expand renewable energy sources to achieve carbon neutrality by 2050 and meet new reduction targets for FY2030.

Challenges and Key Points for Achieving Carbon Neutrality in 2050

- As we approach 2050, efforts in the energy sector, which accounts for over 80% of greenhouse gas emissions, are crucial.
  - ≫ To overcome the challenges to achieving this goal, all sectors of society, including industry, consumers, and government, must work together to achieve this goal.
- In the electricity sector, decarbonization will be steadily promoted by utilizing low-carbon power sources, such as renewable energy and nuclear power, while pursuing innovations like hydrogen and ammonia power generation, as well as thermal power generation based on carbon storage and reuse through CCUS (Carbon capture, utilization, and storage).
- In the non-electricity sector, decarbonized electricity will support increased electrification. In sectors where electrification is difficult (e.g., high-temperature heat demand), decarbonization will be pursued by using hydrogen, synthetic methane, and synthetic fuels. In the industrial sector, innovations like hydrogen-reduced steelmaking and artificial photosynthesis will be indispensable.
- To achieve carbon neutrality by 2050, it is important to secure a stable and affordable energy supply, with safety as a priority. With this goal in mind, to achieve carbon neutrality in 2050, we will work to maximize the introduction of renewable energy as the main power source by giving the highest priority to renewable energy and promote social implementation of hydrogen and CCUS in society. Regarding nuclear power, we will aim to maintain public trust and use nuclear power at a sustainable scale, provided that safety is assured.
- We will pursue all options to achieve carbon neutrality in 2050 while maintaining international competitiveness and reducing the public's financial burden using a stable and inexpensive energy supply.

Key Policy Responses Toward 2030: Demand side's Initiatives

- Further pursuit of thorough energy conservation
  - » Industrial Sector: We will review benchmark indicators and target values and strengthen support for the development and adoption of energy-saving technologies.
  - » Business and Residential Sectors: Efforts will focus on mandating compliance with energy conservation standards under the Building Energy Conservation Law. Additionally, standards for new homes and buildings constructed in and after FY2030 will be raised, as will the Top Runner standards for building materials and equipment.
  - » Transportation Sector: Efforts will be made to expand the introduction of electric vehicles (Evs) and infrastructure, strengthen battery and other EV-related technologies and supply chains, and support new technologies such as AI and IoT, to optimize overall freight transportation through collaboration between shippers and carriers.
- Upgrading of secondary energy structures, including a more effective use of distributed energy resources such as storage batteries, etc.
  - » We will promote efficient energy use through local production for local consumption, resilience enhancement, contribute to regional revitalization, and promote aggregation businesses that utilize distributed energy resources such as storage batteries, and the development of micro-grids.

Key Policy Responses Toward 2030:Demand side's efforts

- With S+3E(Safety + Energy Security, Economic Efficiency, Environment) we will strongly promote renewable energy as a primary power source. Renewable energy will be prioritized, with efforts made on maximizing its adoption, minimizing the public's burden, and fostering coexistence with local communities.

<Specific Efforts>

» Secure suitable sites that promote coexistence with local communities.

→ Facilitate the expansion of solar and onshore wind power by establishing zones that promote renewable energy (positive zoning) and accelerate the development of offshore wind power projects.

» Strengthen business discipline

→ Steady enforcement of technical standards specific to photovoltaic power generation, strengthening of safety measures by enhancing accident reporting for small power sources, etc., and support the formulation of ordinances to promote regional coexistence.

» Streamlining of regulations

→ To facilitate the introduction of wind power generation, we will streamline assessment processes. Additionally, to expand the geothermal power generation, we will review the application of regulations under the Natural Parks Law, Hot Springs Law, and Forestry Law.

» Promotion of technology development

→ We will accelerate R&D and the social implementation of next-generation solar cells suitable for installation on building walls and weak roofs, accelerate the development of elemental technologies for floating solar cells, and develop deep drilling technologies to harness super-critical geothermal resources.

Key Points of Policy Responses Toward 2030: Nuclear Energy

- Sincere reflection on TEPCO's Fukushima Daiichi accident as the starting point for nuclear energy policy
  - If a nuclear power plant is found by the Nuclear Regulation Authority to comply with the world's most stringent regulatory standards, we will respect this judgment and proceed with restarting nuclear power plants on the premise that safety takes precedence over any other factors, with every effort made to address public concerns. The national government will also take the initiative and work to gain the understanding and cooperation of local governments and other stakeholders concerned.
- Promote stable use of nuclear energy based on the premise of gaining public trust and ensuring the safety of nuclear energy.
- Build a relationship of trust with local governments where nuclear power plants are located.
  - We will work to deepen mutual recognition and trust through careful dialogue with municipalities where nuclear power plants are located. Additionally, we will establish a framework for collaboratively envisioning the future of the region, including the creation of new industries and employment, and provide support tailored to regional conditions.
- Promotion of research and development
  - By 2030, while drawing on the ingenuity and wisdom of the private sector, we will steadily promote the development of fast reactors through international collaboration, demonstrate small modular reactor technology, establish key technologies for hydrogen production in HTGRs, and engage in fusion research and development through international collaboration such as the ITER project, among others.

Key Policy Responses Toward 2030: Thermal Power

- The ratio of thermal power generation in the power supply composition should be reduced as much as possible, with the basic premise of ensuring a stable supply.

Key Policy Responses Toward 2030: Electric Power System Reform

- Building an electricity system that ensures a stable supply within the framework of decarbonization.

Key Policy Responses Toward 2030: Hydrogen and Ammonia

- In anticipation of a carbon neutral era, hydrogen is positioned as a new resource, and its implementation in society is being accelerated.
- Establish a hydrogen production infrastructure that utilizes affordable hydrogen from overseas and domestic resources to ensure a stable, large-volume supply of inexpensive hydrogen and ammonia over the long term.
- Expand the use of hydrogen on the demand-side, including in power generation, transportation, industry, and consumer sectors.

Key Points of Policy Responses Toward 2030: Resources & Fuels

- Ensure a stable, uninterrupted supply of essential resources and fuels for the future while promoting a smooth transition to carbon neutrality.
- In addition to the above, we will work to decarbonize the fuel supply system to ensure that it is robust enough to function effectively not only in times of peace, but also in times of emergency.

Key Points of the Energy Supply and Demand Outlook for FY2030 ①

- This outlook presents the projected energy supply and demand for FY2030 under the new reduction target, assuming ambitious measures to address various challenges on both the supply and demand-sides through thorough energy conservation and the expansion of non-fossil energy.
- In implementing these ambitious measures, the intensity and timing should be carefully managed to ensure that a stable supply is not disrupted. For example, immediately curbing fossil power sources before introducing sufficient non-fossil power sources could hinder the stable supply of electricity.

		(FY 2019 => old mix)		FY 2030 mix (ambitious outlook)	
Energy saving		(16.55 million kl ⇒ 50.3 million kl)		62 million kl	
Final energy consumption(before energy saving)		(35 million kl ⇒ 377 million kl)		35 million kl	
Power source configuration Electricity generated: 1,065 billion kWh ⇒ Approx. 934 billion kWh	alternative energy	(18% ⇒ 22-24%)	Solar 6.7% ⇒ 7.0% Wind 0.7% ⇒ 1.7% Geothermal 0.3% ⇒1.0-1.1% Hydro 7.8% ⇒ 8.8-9.2 % Biomass 2.6% ⇒ 3.7-4.6%	36-38%(*)	(Breakdown of renewable energy) Solar 14-16% Wind 5% Geothermal 1% Hydro 11% Biomass 5%
	Hydrogen, ammonia	(0% ⇒ 0%)		1 %	
	nuclear power	(6% ⇒20-22%)		20-22%	
	LNG	(37% ⇒ 27%)		20%	
	Coal	(32% ⇒ 26%)		19%	
	oil free	(7% ⇒ 3%)		2%	
(+ non-energy origin gases and sinks)					
Percentage of GHG reduction		(14% ⇒ 26%)		46%	

*If progress is made in utilizing and implementing the results of ongoing renewable energy R&D, the target will be 38% or higher.

Key Points of the Energy Supply and Demand Outlook for FY2030 ②

- The 3Es if the ambitious outlook is realized

  » Energy Security (Stable energy supply)
  → Energy self-sufficiency ratio (*1) ⇒ Approx. 30% (former mix: approx. 25%)

  » Environment
  → Ratio of energy-derived CO_2 emissions reduction among GHG reduction targets ⇒ Approx. 45% (former mix: 25%)

  » Economic Efficiency
  → Electricity cost if (1) introduction and expansion of renewable energy with lower cost and (2) fossil fuel price decline as forecasted by IEA (*2) are realized.
  ⇒ Total electricity cost: about 8.6~8.8 trillion yen (former mix: 9.2~9.5 trillion yen)(*3)

  about 9.9~10.2 yen/kWh (old mix: 9.4~9.7 yen/kWh)(*4)

*1 In addition to resource self-sufficiency, it is also important to improve the "technology self-sufficiency ratio" (the degree to which energy supply is met by domestic technology relative to domestic energy consumption) by securing core technologies in the supply chain at home and leading the world in such innovation.

*2 The World Bank and EIA (U.S. Energy Information Administration) expect fossil fuel prices to rise in their latest forecasts.

*3 Based on the Power Generation Cost Verification WG (adopting the published policy scenario (STEPS) values from IEA "World Energy Outlook 2020"), FIT purchase cost, fuel cost, and grid stabilization cost are estimated to be about 5.8-6.0 trillion yen, 2.5 trillion yen, and 0.3 trillion yen, respectively (grid stabilization cost includes (Only losses and start-up and shutdown costs due to reduced thermal efficiency of thermal power generation resulting from the introduction of variable renewable energy are included in the grid stabilization costs. The amount may increase depending on actual grid conditions). 4 "Electricity cost" divided by "Power cost".

*4 Calculated mechanically by dividing "electricity cost" by "electricity demand excluding transmission losses, etc., from electricity generation. Different from electricity rates. Actual electricity prices are difficult to forecast accurately, as they include transmission and other charges, and are greatly affected by power supply operating conditions, fuel prices, and electricity demand.

How Can the University Contribute?

- Research on nuclear energy
  - Steady promotion of fast reactor development, research on small modular reactor technology, and nuclear fusion research and development.
- Research on renewable energy
  - Solar photovoltaic, solar thermal, wind, wave and tidal power, water current, geothermal, biomass, etc.
- Introduction of decarbonized fuels and technologies
  - Implement hydrogen, ammonia, and carbon dioxide capture and storage (CCS).
- Research on artificial photosynthesis
- Promote efficient energy use through local production for local consumption, resilience enhancement, and regional revitalization by building microgrids.
- Reduction of CO2 emissions through efforts to reduce electricity consumption on university campuses

Case Studies of Gunma University's Efforts for Energy Transition （1）

Gunma Prefecture Grant Program for Research and Development of Renewable Energy and Decarbonization

Developing a New Industry Platform to Accelerate GX in Gunma Prefecture Through Local Resource Utilization

Design of a Regional Recycling Society with Gunma University’s Gasification Technology at Its Core

■Gunma University's Gasification Technology

- 2006-2010 JST Gunma Prefecture Regional Rally PJ
- 2009-2011 Ministry of the Environment Recycling-based Society Promotion Fund
- 2012-2014 NEDO
- 2013-2020 JST-JICA SATREPS
- 2023- Cabinet Office Regional Bio-Communities
- 2024- Gunma Prefecture Renewable Energy PJ

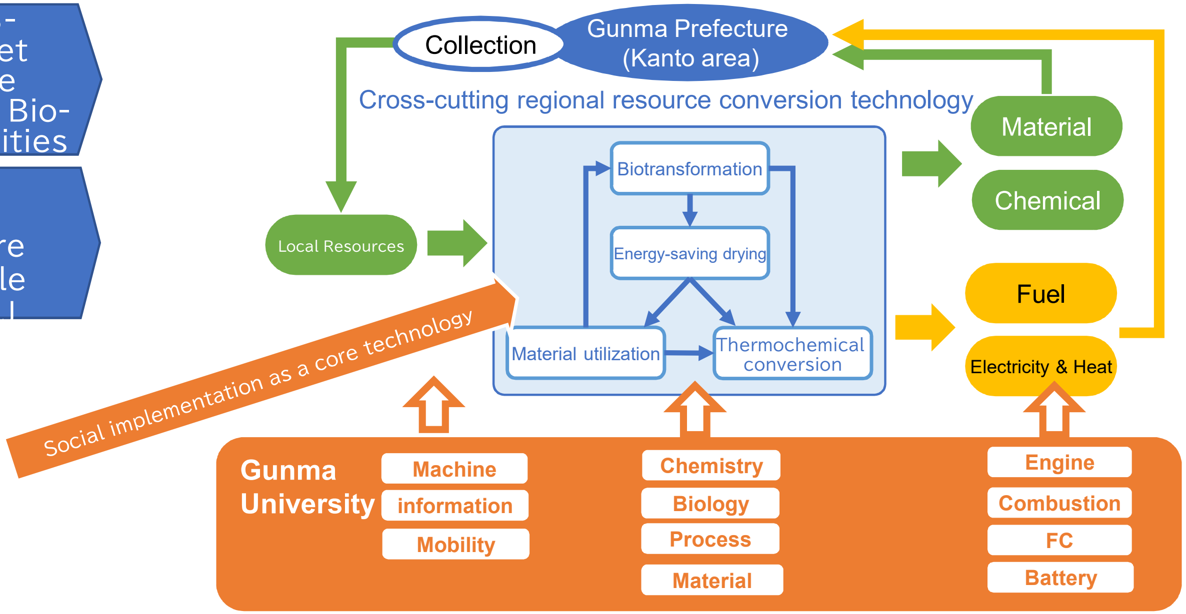
1kg/h Bench furnace

5kg/h Bench

2 t/d Pilot furnace

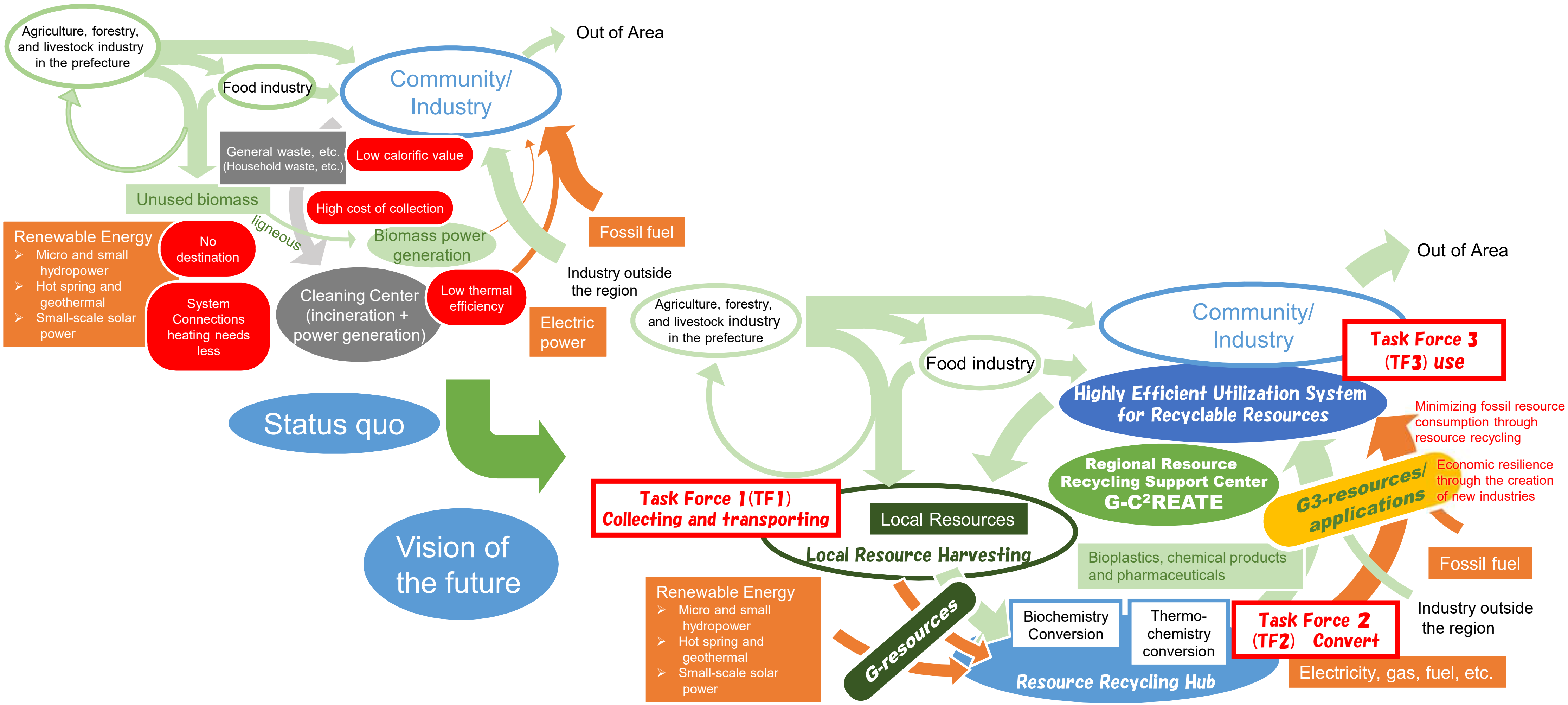
2 t/d Pilot furnace

■ Creating a circular society through collaboration across technological boundaries

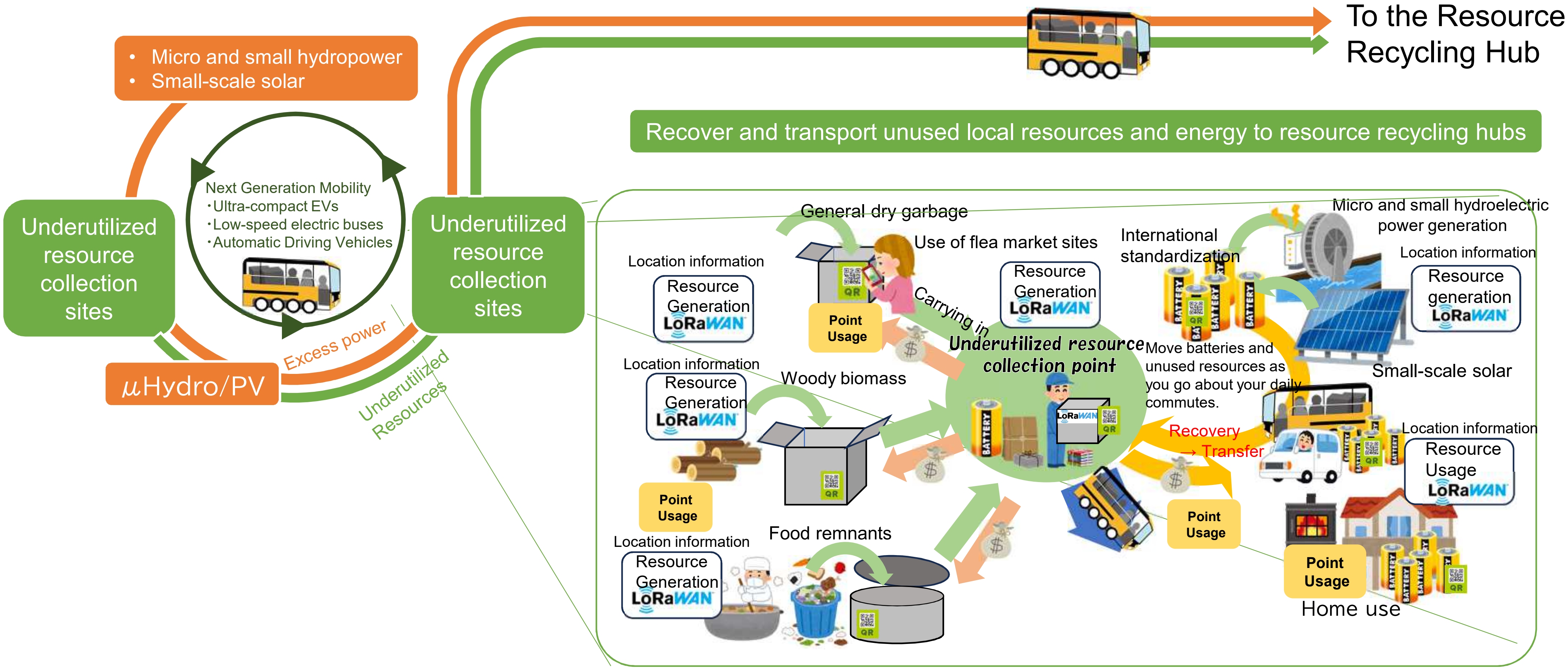


Combining the expertise of Gunma University to realize a new utilization of Gunma Prefecture's resources that transcend the traditional boundaries of research fields.

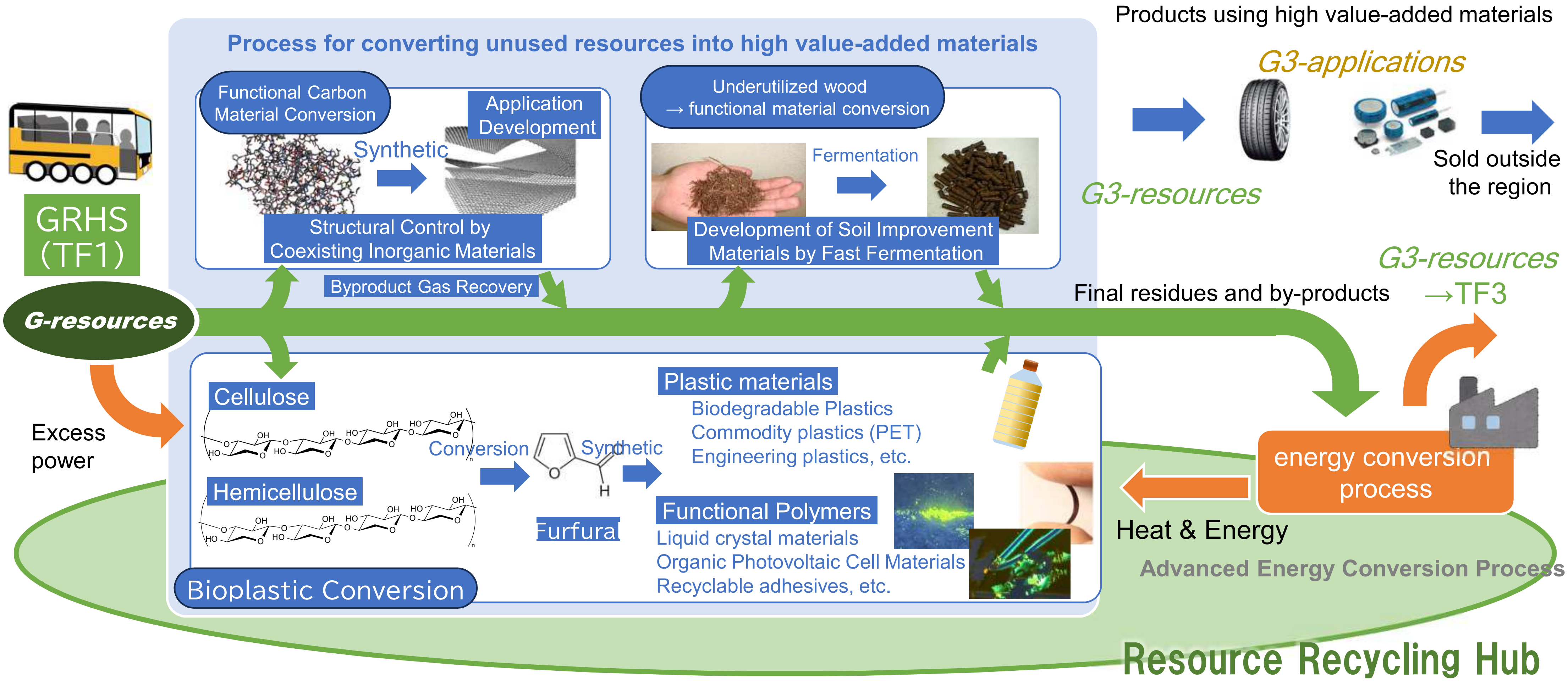
Towards a System That Maximizes the Value of Underutilized Resources



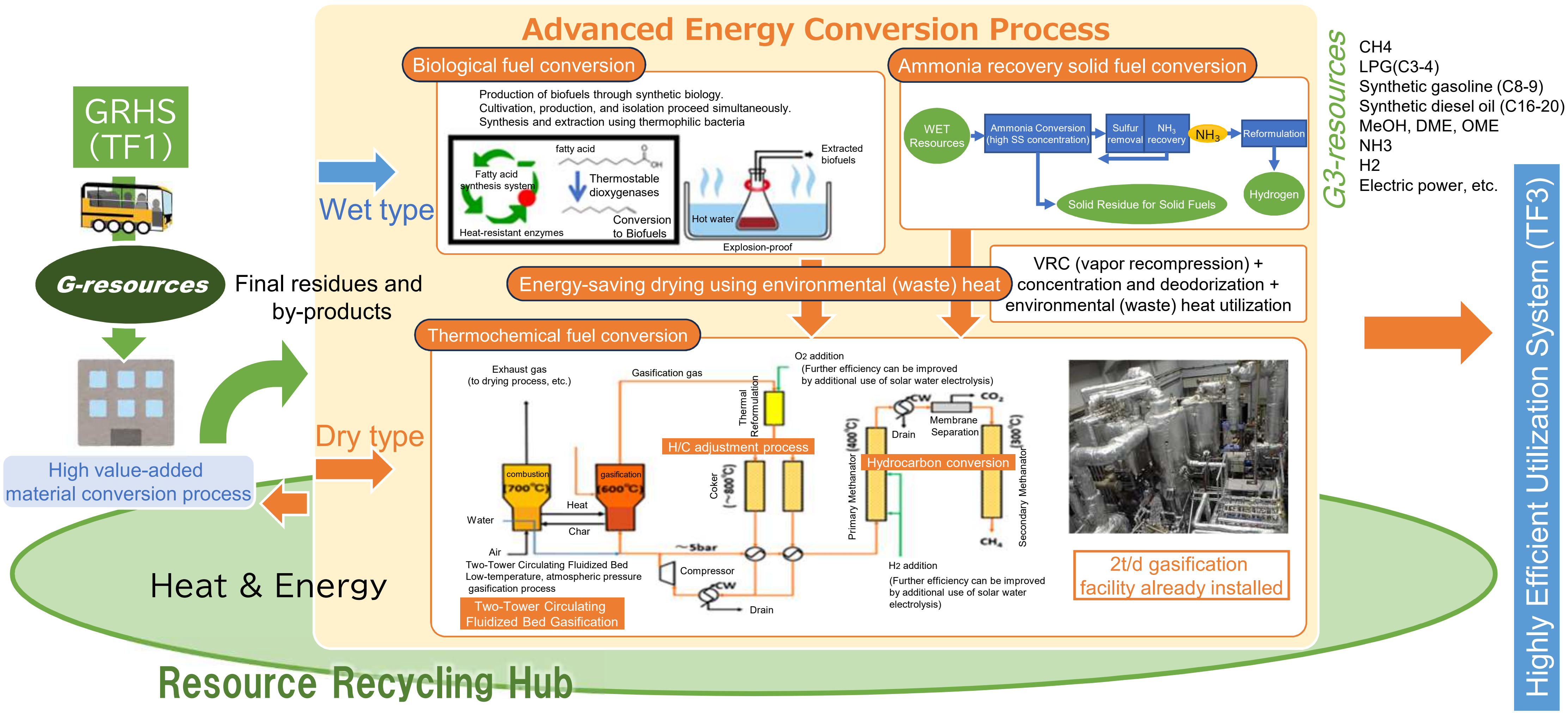
TF1 Local Resource Harvesting Using DX



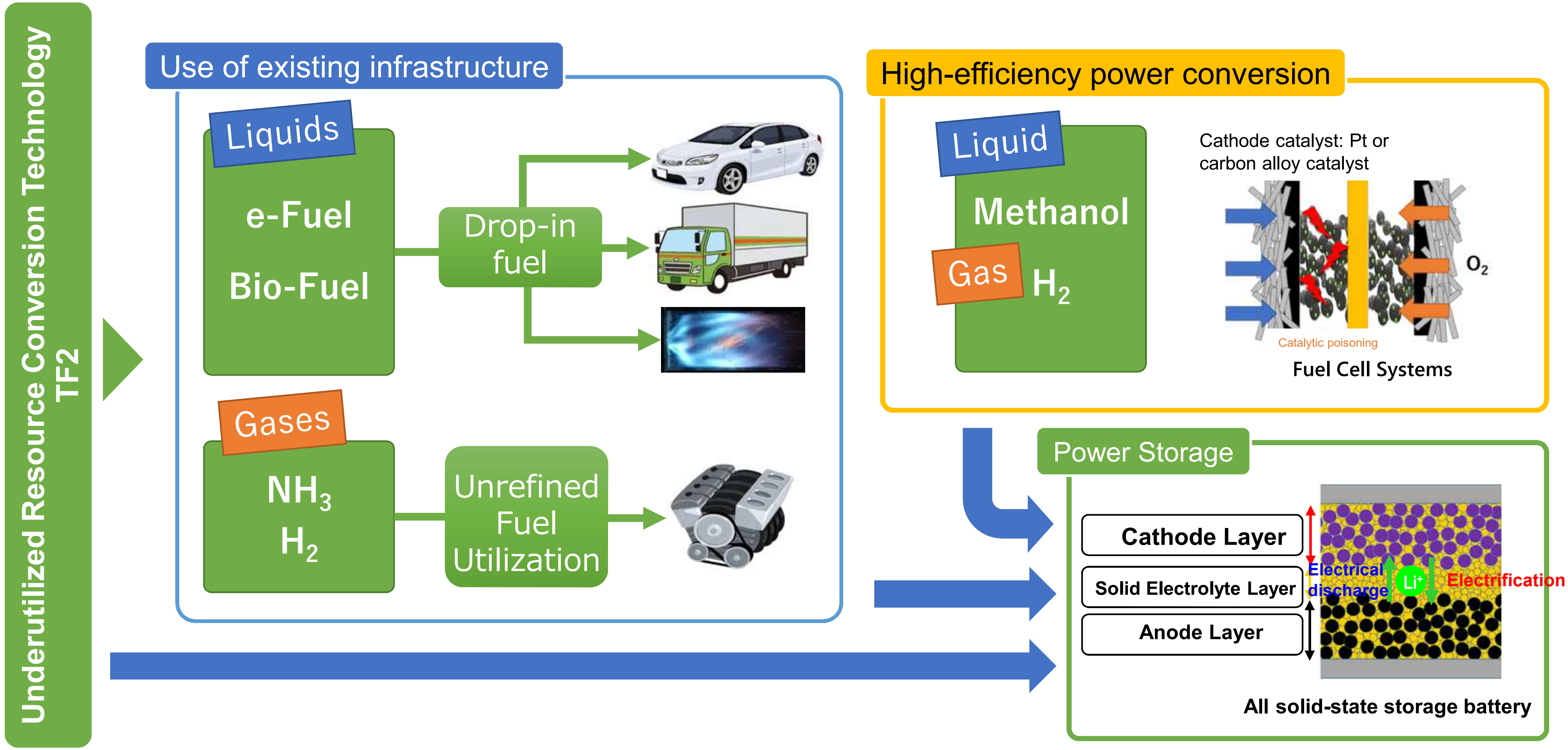
TF2A Converting Unused Resources into High Value-Added Materials



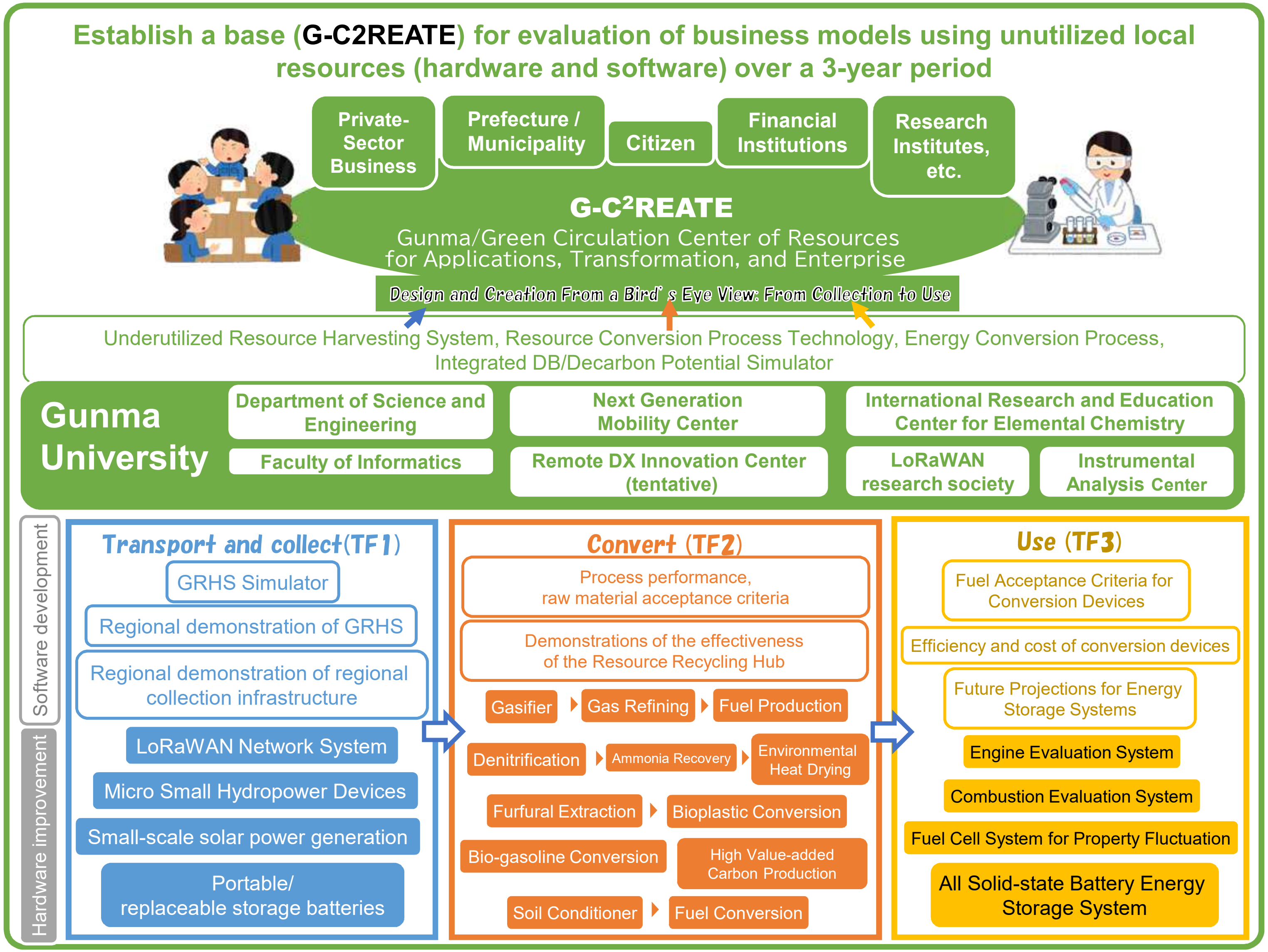
TF2B Energy Conversion of Final Residues



TF3 Synthetic Fuel Utilization System Verification



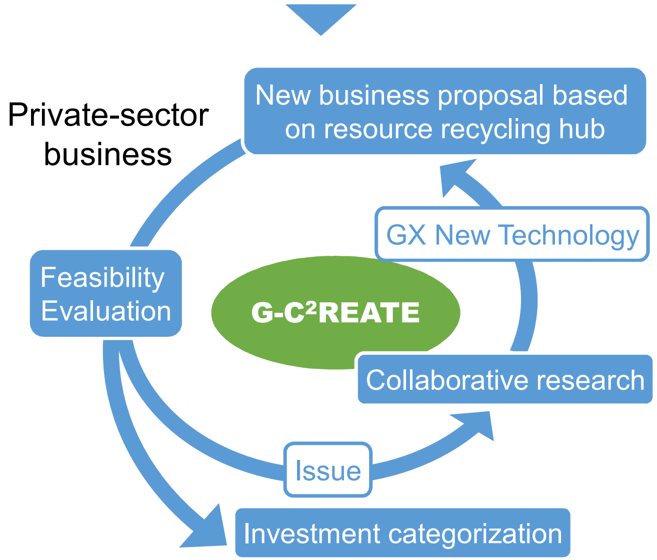
Establishing a Major trend with Local Government and Private Sector Involvement



2027.4～

Initiate the development of GRHS and resource circulation hubs, by applying the Ministry of the Environment's fund for Construction of Circular and Ecological Economy, etc.

※GRHS＝ Green Resources Harvesting System



Accelerate creation of new industries and GX through private investment

Case Studies of Gunma University's Efforts for Energy Transition（2）

Ammonia Production and Utilization Technology

Ammonia: Colored by Hydrogen Production Method

【Gray Ammonia】

SMR：Steam Methane Reforming（Ammonia is synthesized by reacting H_2 (produced from natural gas and water vapor reacted with a Ni catalyst to decompose into H_2, CO, and CO_2) with N_2 separated from the atmosphere, resulting in CO_2 emissions.

【Blue Ammonia】

The production process is the same as gray ammonia, but with carbon dioxide capture and storage, buries it underground. CO_2 separation and cooling technology are required.

【Green Ammonia】

Ammonia is synthesized by reacting H_2 obtained from water electrolysis powered by renewable energy (solar, wind, hydro, etc.) with N_2 separated from the atmosphere. A buffer (battery or hydrogen tank, or ammonia conversion) is necessary to manage fluctuating renewable energy.

Hydrogen color

【Gray Hydrogen】

Hydrogen is produced from fossil fuels, and the CO_2 produced and emitted during the process is discharged directly into the atmosphere.

【Blue Hydrogen】

Hydrogen is produced from fossil fuels. CO_2 is separated, recovered, and stored underground to make it CO_2-free.

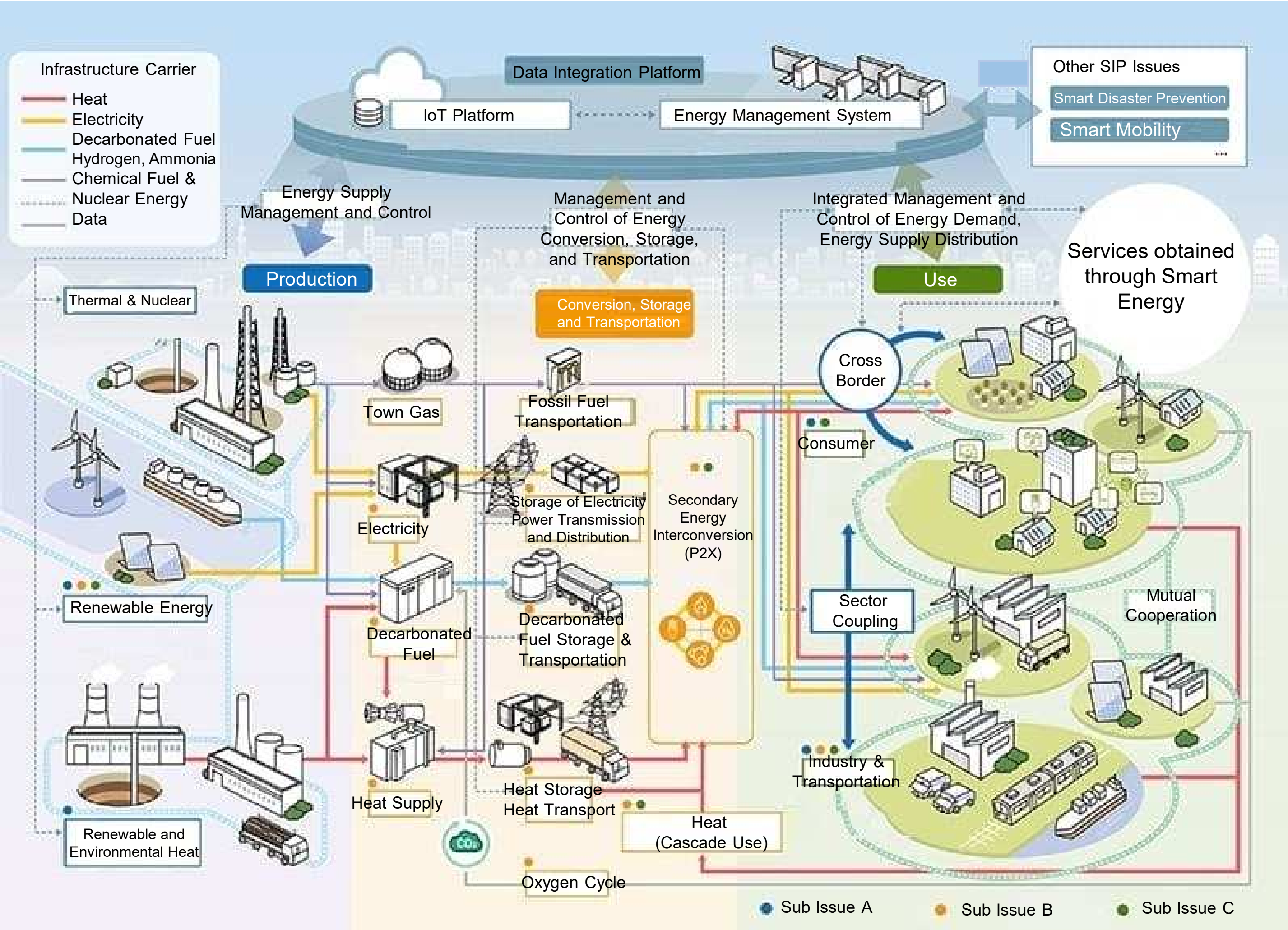
【Green Hydrogen】

Hydrogen produced by electrolysis of water using electricity from renewable energy sources.

Strategic Innovation Program (SIP), Cabinet Office, Government of Japan

『Development of a Smart Energy Management System』

https://www.jst.go.jp/sip/sems/index.html
https://www8.cao.go.jp/cstp/gaiyo/sip/sip_3/keikaku/smartenergy.pdf



Building a cross-border, cross-sectional ‘smart energy management system’ primarily based on renewable energy to achieve carbon neutrality, energy security, and Society 5.0.

【Subproject A】
Energy and Mobility, etc.

【Subproject B】
Energy production, conversion, storage, and transportation

【Subproject C】
Optimal energy use

Strategic Innovation Program (SIP), Cabinet Office, Government of Japan

Research and Development Themes
Subproject A (Energy and Mobility etc.)
A1 Energy and Mobility Sector Coupling
A2 Development of Rural VPPs to achieve RE100
Subproject B (Energy Production, Conversion, Storage, and Transportation)
B1 Distributed Energy System Using Ammonia and Hydrogen
B2 Carbon Neutral Mobility Systems
B3 Development of intelligent power electronics system with USPM to support grid stabilization
Subproject C (Optimal Use of Energy)
C1 Area Energy Management System Platform Development and Implementation
C2 Development and Commonality of Fundamental Technologies for Thermal Energy Management Systems
C3 Development and Implementation of an Industrial Smart Energy Management Collaborative System

内閣府 Cabinet Office　経済産業省 Ministry of Economy, Trade and Industry　文部科学省

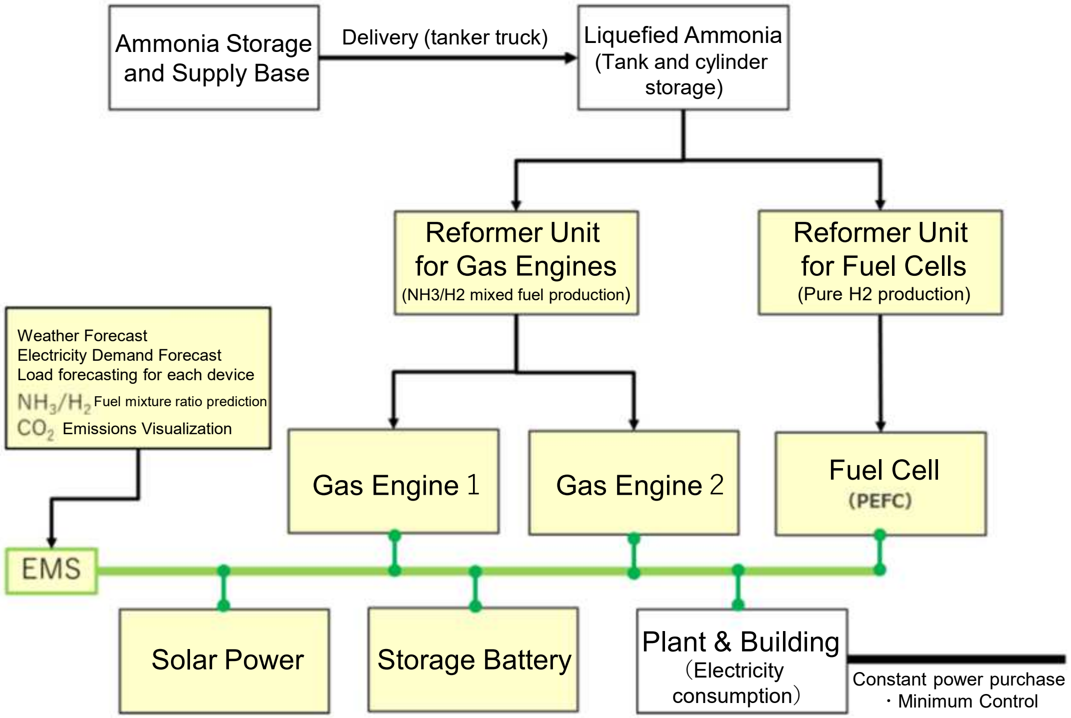
- All-Japan project linking industry, government, and academia across ministries and agencies
- Approx. 50 participating companies
- Approx. 50 participating universities
- Five Initiatives:
  ① Technology development
  ② Business development
  ③ Social system
  ④ Social acceptability
  ⑤ Human resource development

Development of a Distributed Energy System Using Ammonia and Hydrogen

『Development of a Smart Energy Management System』

Subproject B1: Distributed Energy Systems Using Ammonia and Hydrogen

PD: Shinji Kambara, Gifu University **Sharing:** Mikiya Araki, Gunma University.



【Partial reforming of ammonia to hydrogen】

Ammonia burns. It burns so well that it can be used in engines to generate electricity, but the flame is quickly extinguished. A portion of the ammonia is reformed, and hydrogen is extracted to replace the ammonia in the fuel that is difficult to burn. This requires precise control.

【Energy Management System (EMS)】

Predicts power consumption based on weather conditions and actual consumption data, and coordinates the control of solar power generation, gas engines, and fuel cells. The ammonia/hydrogen mixing ratio is also integrated and controlled in real time.