Piezoelectric Harvesting Technology in Busan Port

- Current Status & Future Tasks -

2024. 09. 25.

BPA | 부산항만공사
BUSAN PORT AUTHORITY

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PART
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Overview

01. Background

Need for New Energy Measures

New Energy required for the Increase in electricity use due to automation technology & environment regulations

- **Busan port Annual energy consumption : 60Million USD, Electricity 56.2%, Diesel 32.6%,LNG11.2%**
  * Electricity consumption is continuously increasing as a proportion of total energy usage

Busan Port receives 100% of its electrical energy supply from Korea Electric Power Corporation (KEPCO)

- **With the Introduction of AGV , AMP, etc, A significant increase in Electricity consumption is expected**
  * AGV deployment plan: 65 units in Phase 2-5 (2023), 40 units in Phase 2-6 (2026), and more than 20 units per berth at Jinhae New Port

2021 Status of Port Handling Equipment and Greenhouse Gas Emissions at Busan Port

Equipment	Energy	Units	Consumption	Gas Emissions(tCO2eq/Unit)	Unit Gas Emissions(tCO2eq)
Yard Tractor	Diesel(1,000ℓ)	289	7,559	20,060	69.4
	LNG(Ton)	397	13,003	37,874	95.4
Transfer Crane	Diesel(1,000ℓ)	36	4,910	13,031	362.0
	Electricity(MWh)	336	124,079	57,002	169.6
Straddle Carrier	Diesel(1,000ℓ)	36	3,681	9,768	271.3
Reach Stacker	Diesel(1,000ℓ)	45	2,330	6,183	137.4
Empty Handler	Diesel(1,000ℓ)	59	2,406	6,384	108.2
Fork Lift	Diesel(1,000ℓ)	58	553	1,282	22.1
Container Crane	Electricity(MWh)	119	89,060	40,914	343.8

「Busan Port 2050 Carbon Neutrality Comprehensive Plan", Busan Port Authority Final Report (February 10, 2023), Page 201.

01. Background

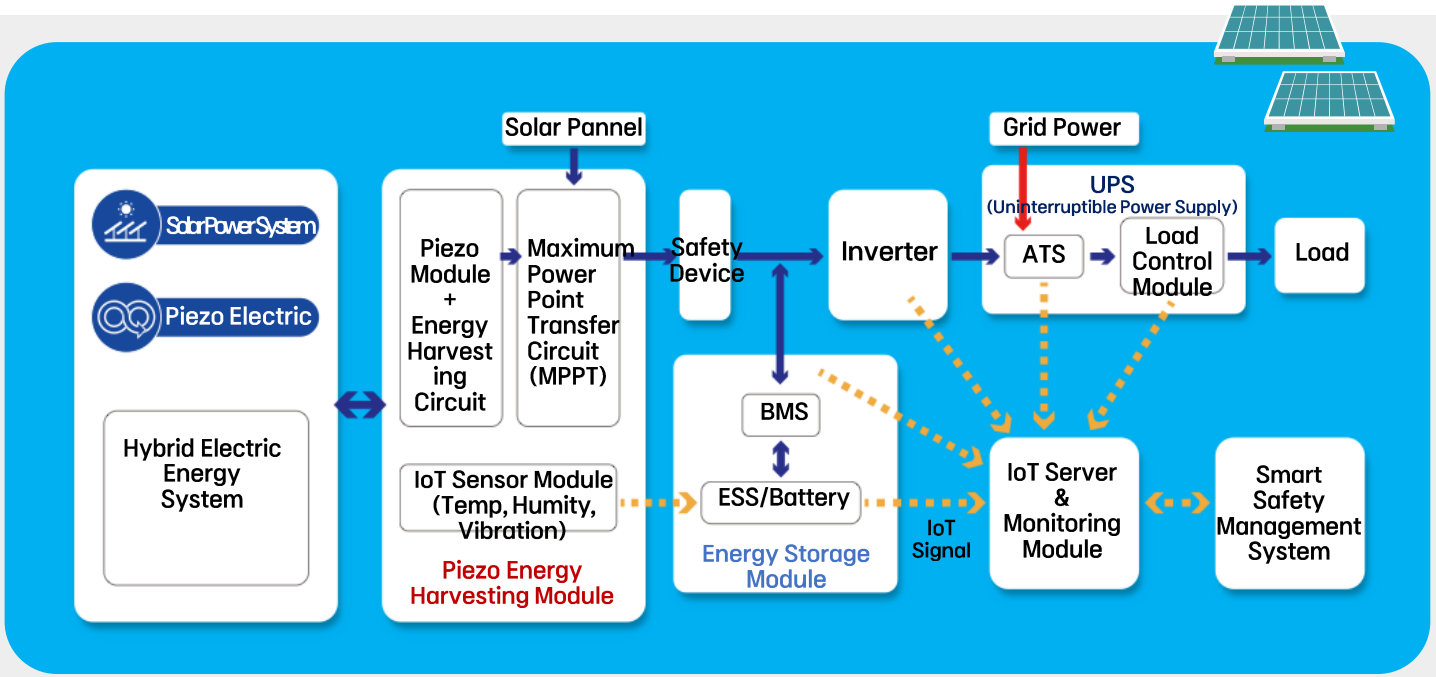
Development of Port-Specialized Advanced Energy Technology

reflecting the characteristics of ports, such as frequent visits by cargo trucks and access restricted to the gates

- vehicles generate electricity by driving over piezo modules, which is then supplied to the port or nearby residents
  * The annual number of truck visits 1 million (based on 3 berths), resulting in about 15 million vehicle passages across Busan Port as a whole

- Securing competitiveness in comparison with solar power – costs, space, climate impact, and generation capacity
  * Pursue cost reduction and increased energy generation to achieve economic viability compared to solar power, based on the same output

Concept Diagram of a Piezoelectric for Port Gates



PART
02

Results

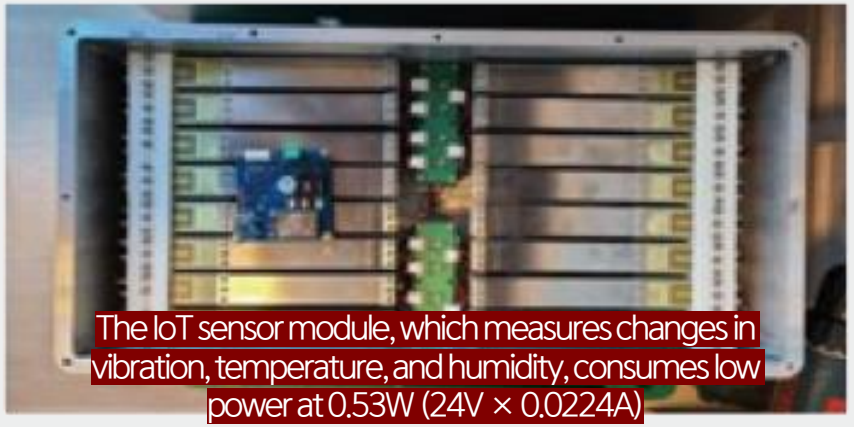
Results

01. IoT Sensor & Module Development

IoT Sensor Module

IoT Sensor Module

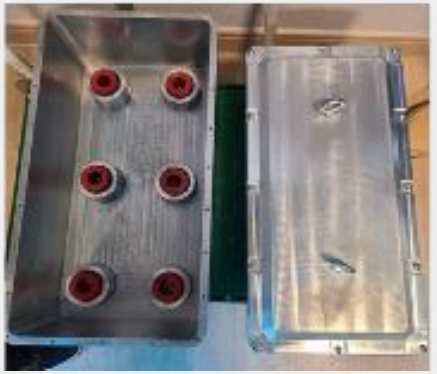
Power Consumption Test



The IoT sensor module, which measures changes in vibration, temperature, and humidity, consumes low power at 0.53W (24V × 0.0224A)

Image of the IoT sensor module installed

Piezo Module & Case



Case of Piezo Module

Top of Piezo Module

Bottom of Module

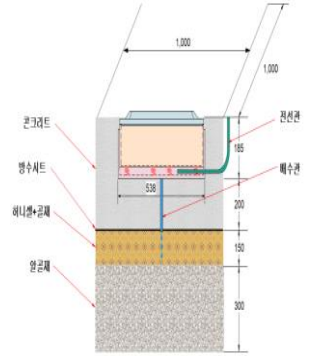
Internal Components

Results

02. Conducting a Testbed & Preliminary Test

- Utilize the marine industry cluster
- Integrated testing of individual modules
- Estimate expected power output

Overview of the marine industry cluster site



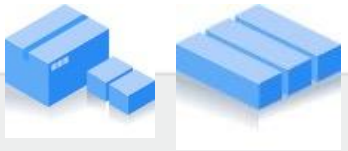
cross-section

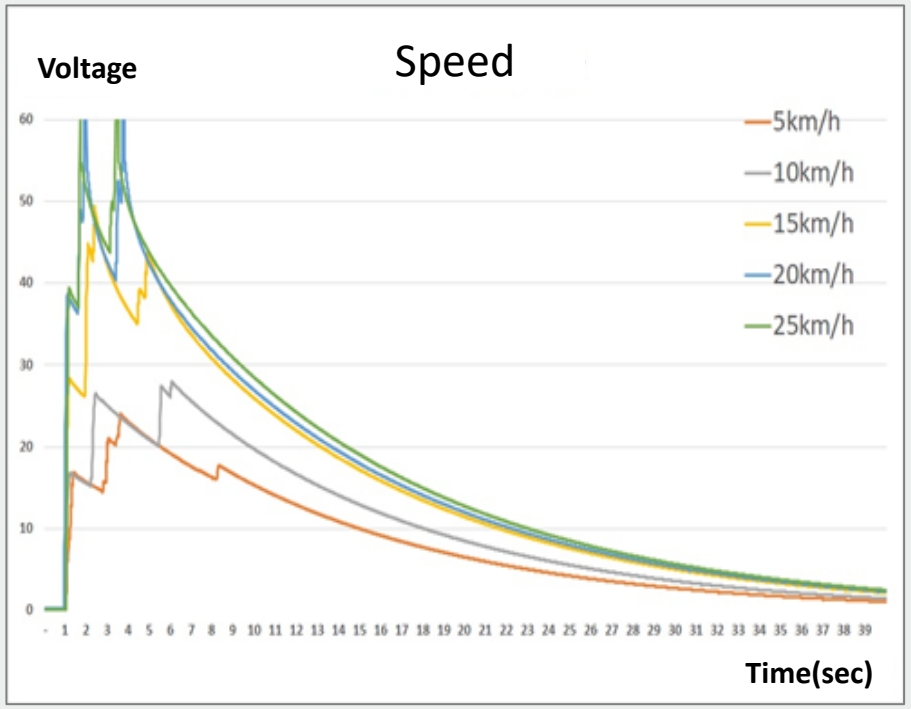
Installation

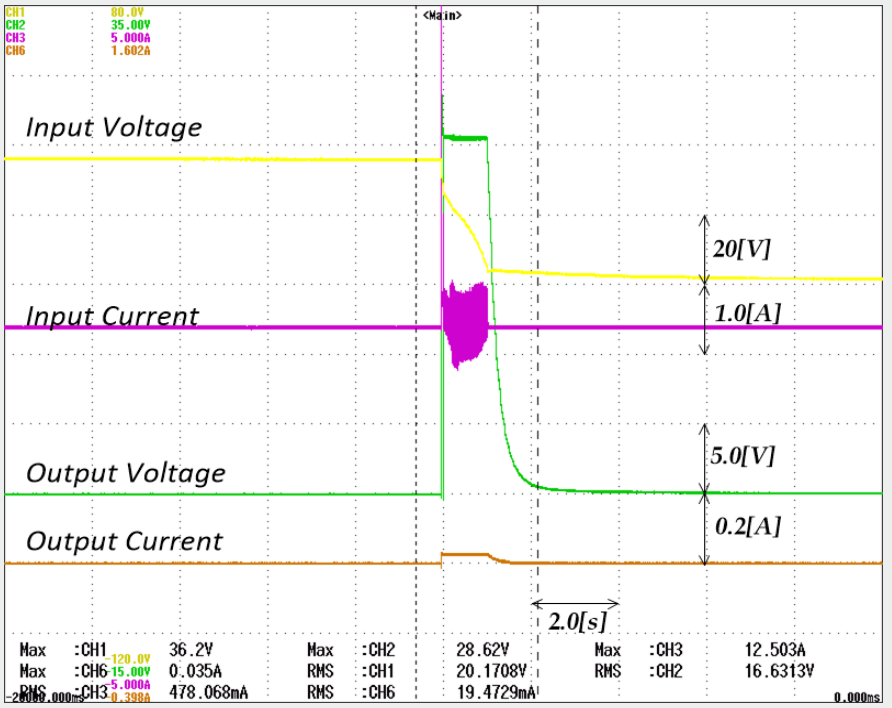
power calculation

Results

03. Results of Preliminary Test







- Minimal impact on cargo weight(load/emp)
- Voltage is higher when driving 20~30km/h

Speed [Km/h]	Num	Voltage [V]	Output Energy [J], [Ws]	1 Set Output Energy [J], [Ws]
30	5	36	1.4256	5.7024

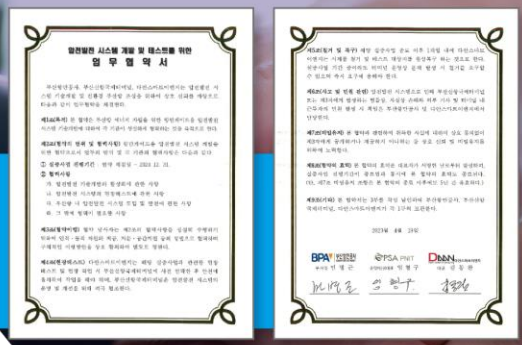
Results

04. Collaboration with Terminal Operator

Testing of the piezoelectric power generation system

BPA PNIT Daan

Signing of a MOU



05. Installation of Module

initial installation

- Eight piezoelectric modules were installed on one lane, and issues such as alignment problems were identified

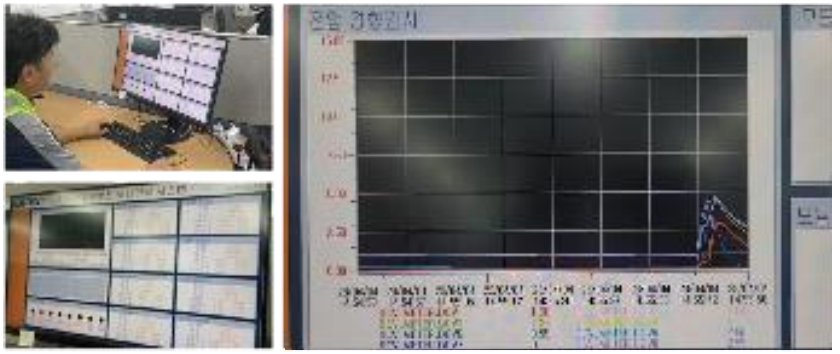
Outbound gate at Pier 1 of Busan New Port

- Improvement of alignment and completion of leveling
- Painting of the top surface of modules helped reduce resistance from truck drivers to driving over

Modules after alignment and leveling work

06. Remote and on-site monitoring systems

Installation of on-site monitoring panels



Interface of Remote & Monitoring System

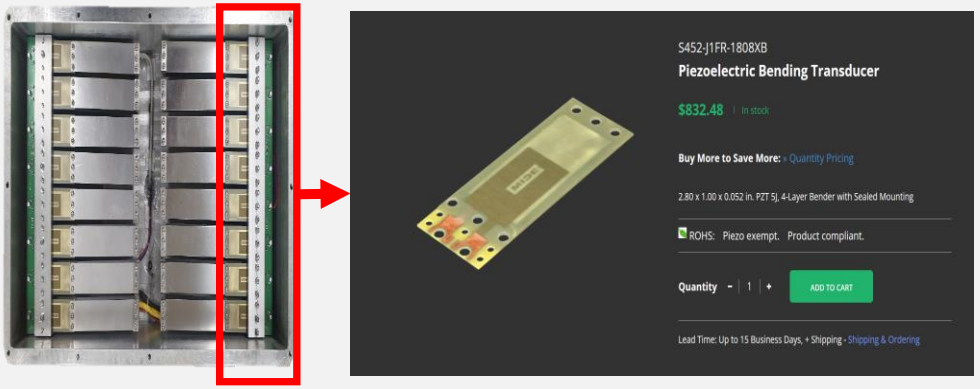
07. Validation analysis with 20,000 vehicles

Overview of the piezoelectric generation testbed

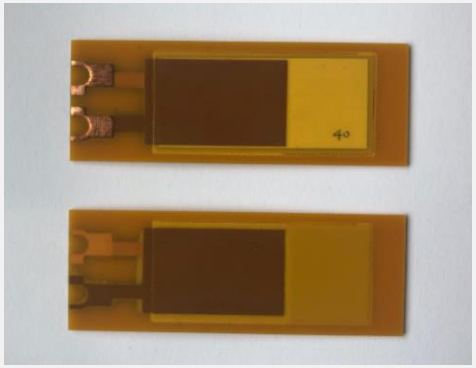
Video of vehicle passage

Results

08. Localization and verification of piezoelectric devices

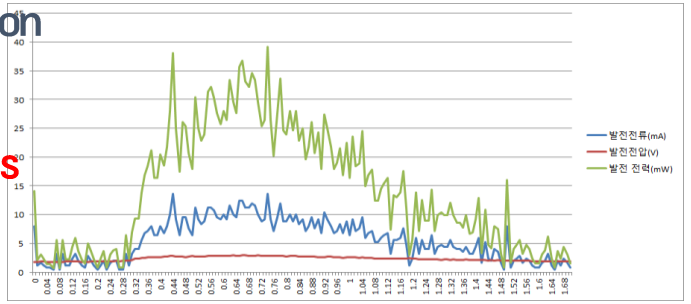


- Use of piezoelectric devices from 2–3 global piezoelectric distributors
- The minimum order is 200 units, requiring a high purchase cost
- Future efforts will focus on reducing production costs through R&D



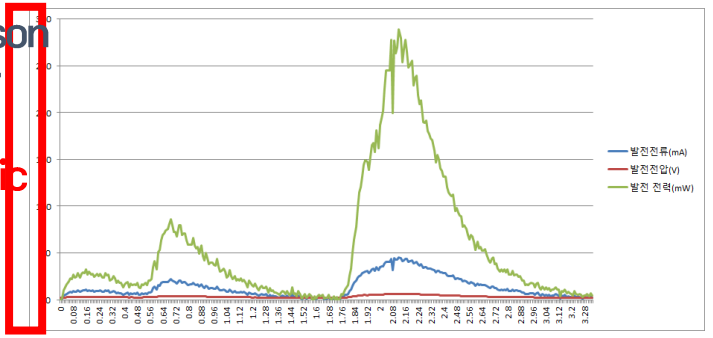
- Efficiency is 4 to 6 times higher, while the price is one-fifth

Comparison of power output -Overseas



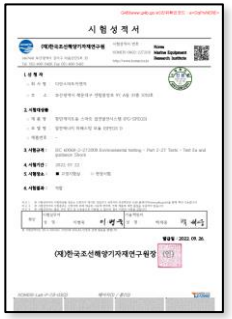
	Output per vehicle (W)	Output per sec (W/s)	Output per hour (kW/h)
Test #01	0.251184762	0.24152381	0.869485714
Test #02	5.547724693	1.213944134	4.370198883
Test #03	2.416855205	1.421679532	5.118046316
Mean	2.73858822	0.959049159	3.452576971

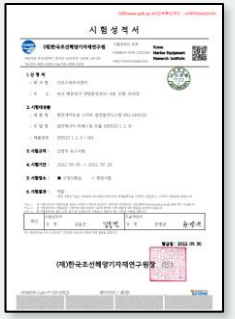
Comparison of power output -Domestic



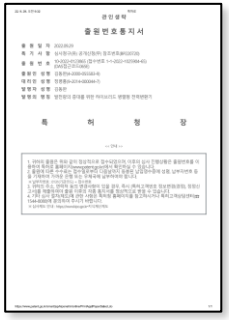
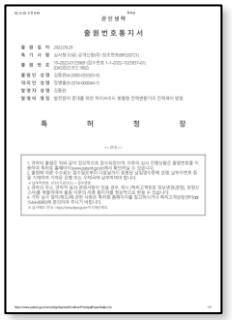
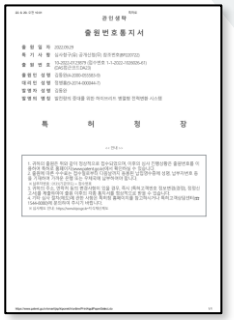
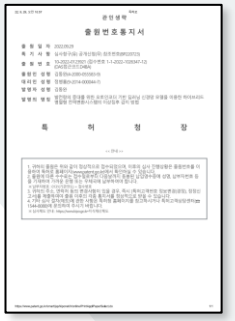
	Output per vehicle (W)	Output per sec (W/s)	Output per hour (kW/h)
Test #01	14.13167471	4.072528736	14.66110345
Test #02	22.06056998	5.407002445	19.4652088
Test #03	12.07346723	3.37247688	12.14091677
Test #04	18.9326492	5.68548024	20.46772886
Mean	16.79959028	4.634372075	16.68373947

09. Official Certification Test Report(11cases)

10. Intellectual Property Rights (Reg 1, App 4)

11. IAPH, Sustainability Report (WPSP)

PART
03

Future Tasks

Future Tasks

Enhancing Durability and Commercial Strategies

Future Tasks	2024								2025			
	5	6	7	8	9	10	11	12	1	2	3	4
⟩⟩ Enhancement of Durability and Maintenance – Change of housing material (Aluminum → Stainless Steel) – Application of EPDM (rubber material) to housing covers												
⟩⟩ Enhancement of output and validation of vibartors – Manufacture and testing of new devices and modules												
⟩⟩ Reduction of power loss, Enhancement of output – Validation and new implementation of converter chip												
⟩⟩ Commercialization strategies and feasibility analysis – Technical Analysis: IP rights & demand analysis – Financial Analysis: Estimated profit, business plan analysis												

Thank you
감사합니다.

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