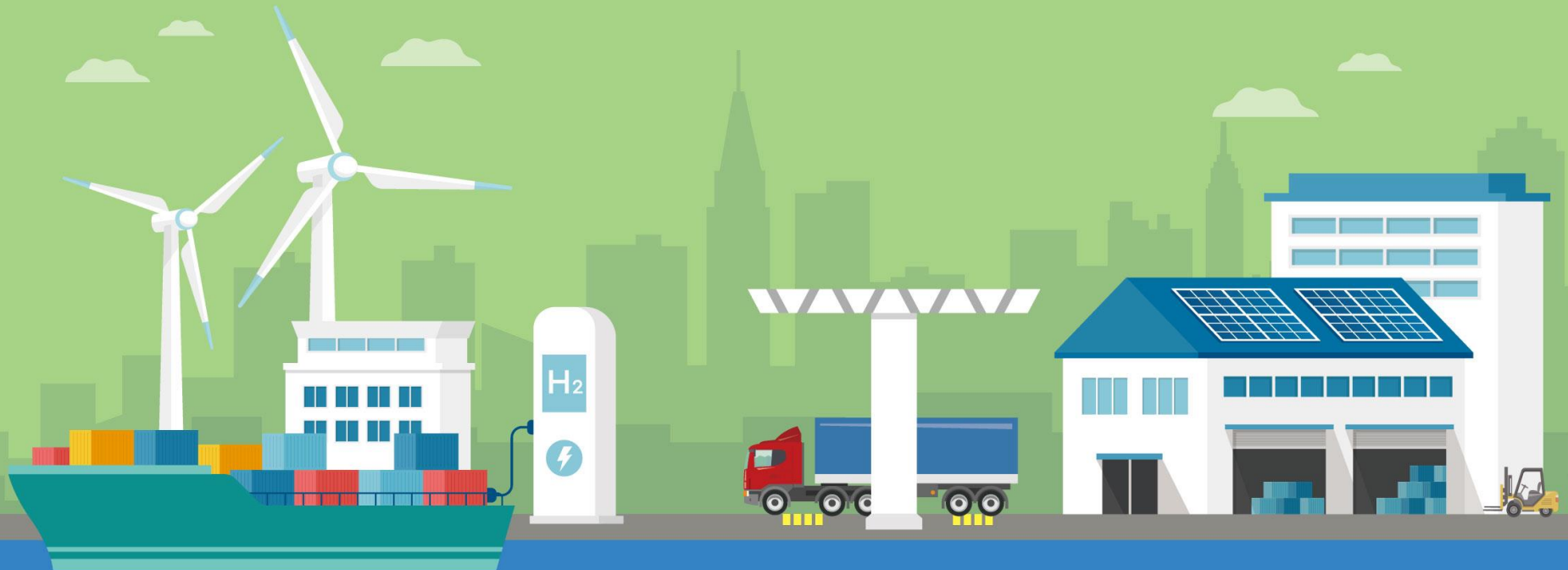




# Development and Demonstration of a Smart Piezoelectric System for Port Gates



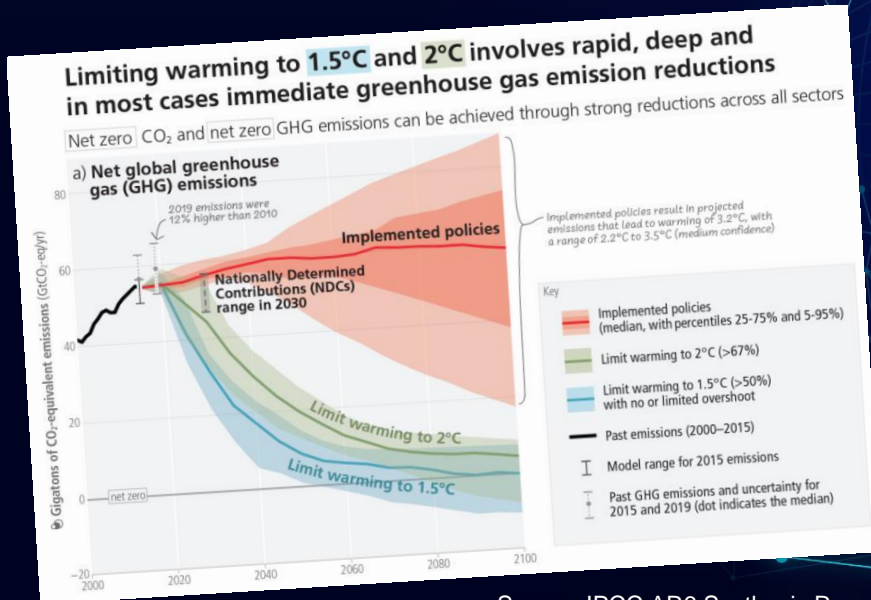


IPCC Report

In order to limit global warming to 1.5 degrees Celsius by the turn of the century, the world needs to achieve net-zero carbon dioxide emission by 2050...



- Nations around the world are adopting eco-friendly energy policies.
- Ports across the globe are setting ESG targets for the reduction of GHG emissions, including the introduction of renewable energy sources
- South Korea has updated its NDC target to reduce its GHG emissions by 40% of what they were in 2018 by 2030



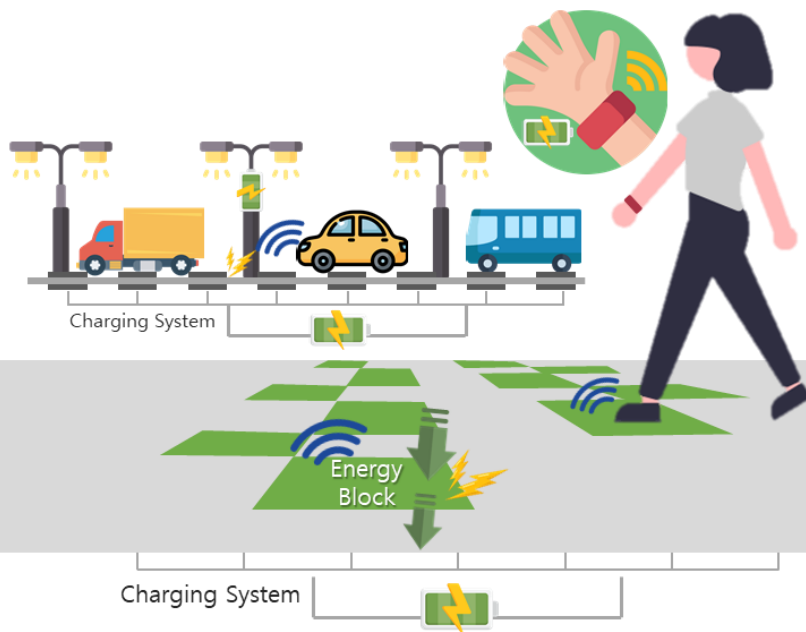
Source: IPCC AR6 Synthesis Report

## Why do we need this initiative?

- ✓ Electricity consumption is increasing with the pursuit of low carbon emissions and eco-friendly smart ports
- ✓ While the distribution of renewable energy is increasing, constraints due to space, weather, and other factors, means that there are limitations when it comes to securing renewable energy source

Utilising its characteristics as a port, Busan Port will overcome these limitations, using **piezoelectric energy generated vibration and pressure** of cargo trucks during passage

### Piezoelectric Harvester



### [Characteristics of piezoelectricity vs. renewable energy]

	Wind	Solar	Geothermal	Hydro	Coal-fired	Piezo
Generation cost per 1kWh (cent)	3~10	10~20	2~10	2~10	8~10	3~10*
Payback period (year)**	12~30	20~30	10~20	12~15	15~20	6~12*
Sustainability	X	X	✓	✓	✓	✓
Cleanness	✓	✓	✓	✓	X	✓
Maturity of technology	✓	✓	✓	✓	✓	X
Ease of installation/modification	X	X	X	X	✓	✓
Feasibility of installation in urban areas	X	✓	X	X	X	✓

[Basis for calculation : \* traffic-dependent, \*\* Assuming 10cent in revenue per kWh] / Source : Israel

### [Economy of piezoelectricity vs. solar]

Category	Solar power generation	Piezoelectricity
Power generation per year	Approx. 45MWh	Approx. 45MWh
Installation cost	KRW 87 mil. on average	Approx. KRW 82 mil.
Area required	Approx. 50m <sup>2</sup>	Approx. 12m <sup>2</sup>
Payback period	Approx. 8 years	Approx. 7.5 years

## How are we able to harvest piezoelectric energy at ports?

By addressing the limitations of piezoelectric energy on public roads.

01

### Uniform weight

of loaded / empty trucks

02

### Regular pace

Speed is limited during gate entry/exit

03

### Identical path

Gate passage is mandatory for all trucks

## Development and demonstration of smart piezoelectric system for port gates

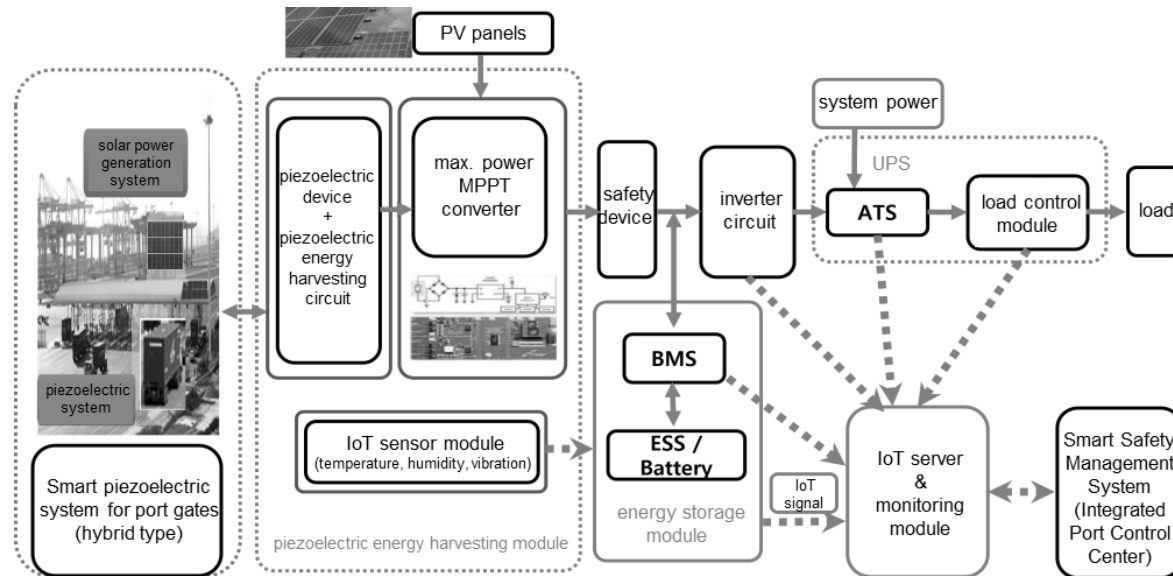
### Project Overview

The development of technology which converts the pressure and vibration generated by container trucks entering and leaving the port terminal gates into electricity for storage and use

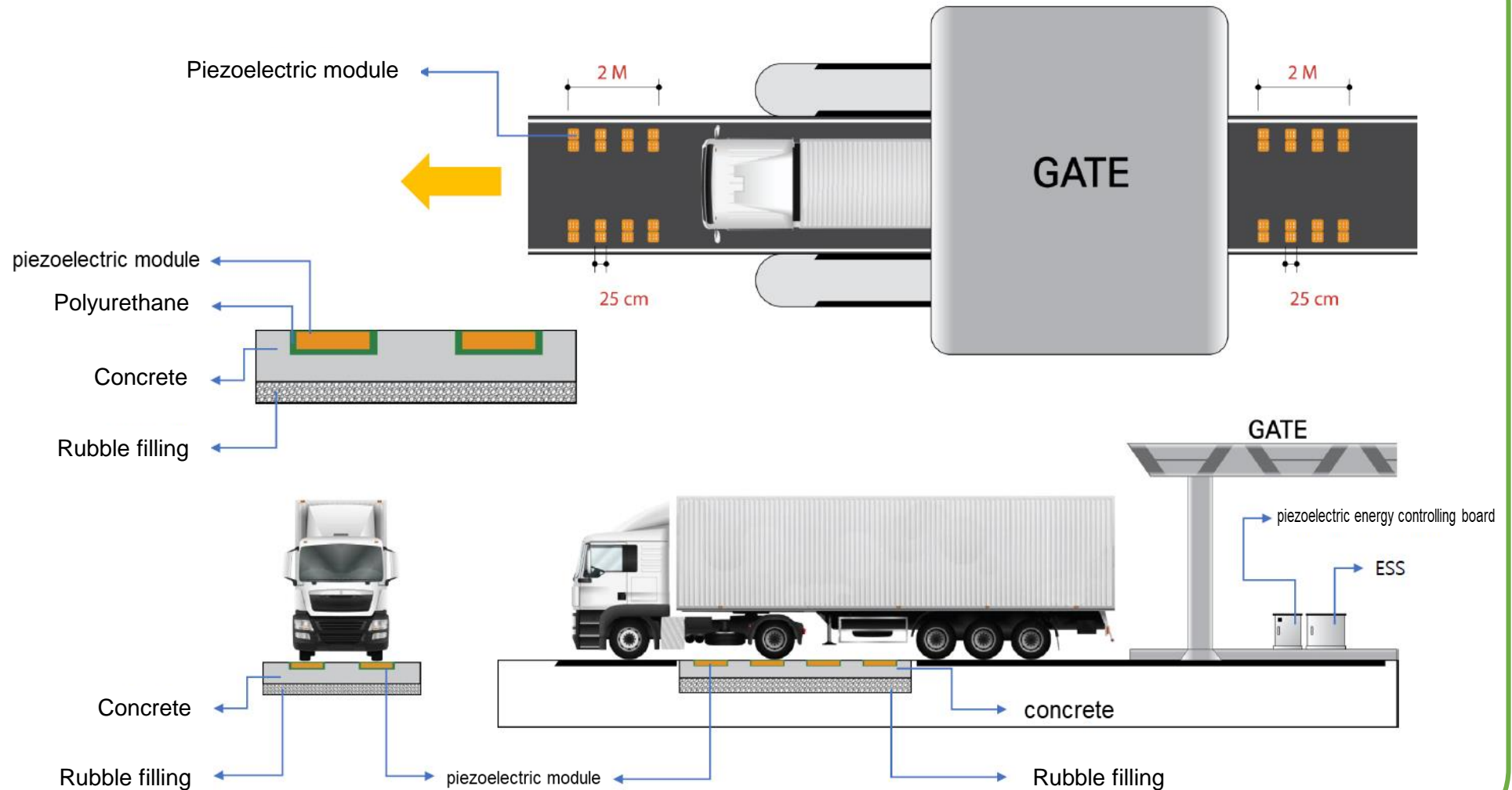
### Project period

November 1, 2021 ~ October 31, 2023 (24 months)

### Process



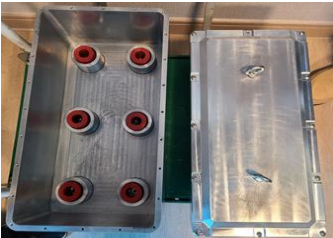
### Conceptual overview of piezoelectric system



- Jan. 12, 2022 Technology development launch report and collection of stakeholder input
- Mar. 4, 2022 Field investigation into terminal gates at Pier 1 of Busan New Port (PNIT)
- Apr. 2022 Completion of development of piezoelectric modules and IoT sensor modules
- Aug. 2022 ~Mar. 2023 Selection of Uam Pier as a test-bed, and identification of issues via field tests
- Aug. 2022 Durability testing of piezoelectric modules (temperature & humidity, dustproofing), and receipt public certification
- Sep. 2022 Completion of piezoelectric system installation manual
- Sep. 29, 2022 Application of four patents
- Dec. 28, 2022 Pre-inspection of piezoelectric system demonstrative review (PNIT)
- Feb. 7, 2023 Testing of field/remote monitoring system communication



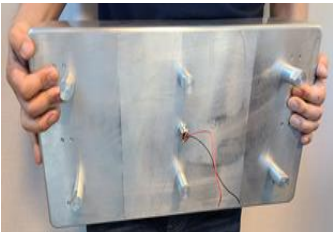
## Piezoelectric modules and casing



[piezoelectric module case]



[upper part of the module]



[lower part of the module]



[inside of the module]

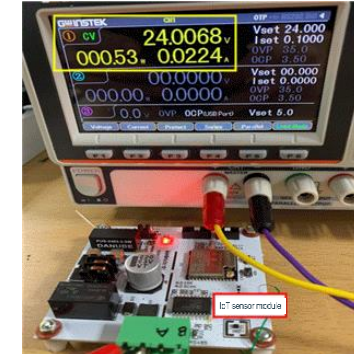
## IoT sensor modules



[IoT sensor module]



[IoT sensor module installed]



[IoT sensor module power consumption testing]

The IoT sensor module, which measures changes in vibration, temperature, and humidity, consumes only 0.53W ( $24V \times 0.0224A$ ).

## Pre-testing of piezoelectric module

- Maritime industry cluster used as a testing site
- Issues resolved through integration testing for modules
- Expected power generation estimated through mock testing



[View of maritime industry cluster site]

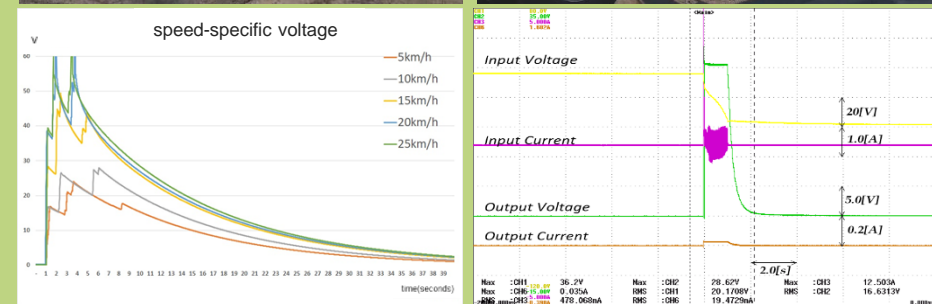
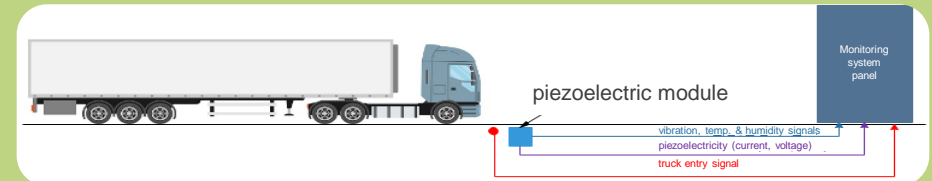


## In-field pre-testing results

**Testing subject** Two piezoelectric modules and 64 piezoelectric devices

**Piezoelectric module output** Condenser (2,200 $\mu$ F, 50V)

**Testing conditions** Repetition of truck operation five times at the speed of between 5~30km per hour



Speed [km/h]	No. of operations	Piezoelectric device output voltage [V]	Output energy of two piezoelectric modules [J, [Ws]	Output energy of one piezoelectric harvesting set [J, [Ws]
30	5	36	1.4256	5.7024

Demonstrative testing underway, following installation at Pier 1 of the New Port



(This picture will be submitted as a video)



- Installation of piezoelectric system (Mar. 2023)
- Demonstration of piezoelectric system (Mar. ~ Oct. 2023)
- Additional patent application on core technology of piezoelectric module (2023) (application for four patents completed in Sep. 2022)

Installation will commence at all piers of Busan New Port following the results of the tests at Pier 1 of the New Port and enhancement / improvement of piezoelectric device



Installation at 47 gates across six piers of the New Port terminal



# Anticipated benefits from the installation of a piezoelectric system at Busan New Port

## Economic effect

**Generation of 2,115MW in electric energy per year to power 705 households for one full year**

- \* [Expected power generation] Generation of 45MW per lane per year × 47 lanes
- \* [Energy available for use] 2,115MW / (monthly average electricity consumption per household in Busan as of 2022 (250kwh) × 12 months)

## Environmental benefits

**Approx. 936,522 ton reduction in CO<sub>2</sub>-eq  
Equal to planting 149,428 pine trees**

- \* [CO<sub>2</sub> emissions reduction calculation formula]  
19.926ton CO<sub>2</sub>-eq of expected CO<sub>2</sub> emissions reduction per lane × 47 lanes  
[KCEN carbon footprint calculator]

# Busan Port : leading the way in energy self-sufficiency with piezoelectricity!

