GridSTART
Hawai'i Natural Energy Institute | University of Hawai'i
Grid System Technologies Advanced Research Team

Waste Management of Clean Energy Products in Hawai'i and Recommendations to Pacific Region

Deep Dive Workshop, Renewable Energy Waste Management in the Pacific
Asia Clean Energy Forum 2025
ADB Headquarters, Manila, Philippines | June 6, 2025, 11:00 a.m. – 12:30 p.m. (GMT +8)

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HNEI
Hawai'i Natural Energy Institute
University of Hawai'i at Mānoa

UNIVERSITY of HAWAI'I MĀNOA

Hawai'i Natural Energy Institute
School of Ocean & Earth Science & Technology
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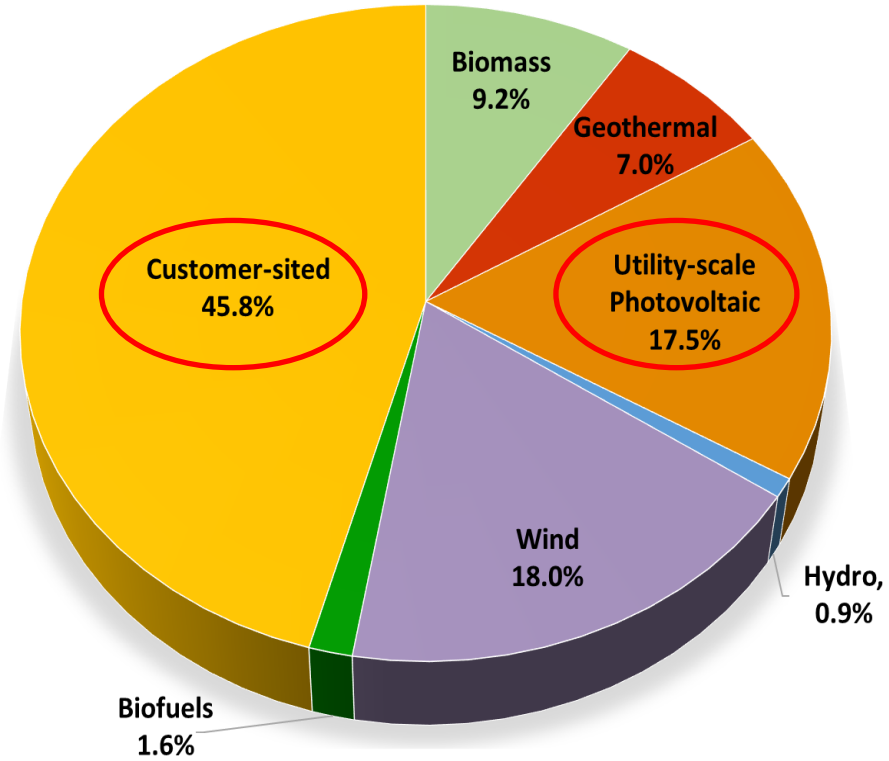
Hawaii's Current RE Status & RE Waste Volumes

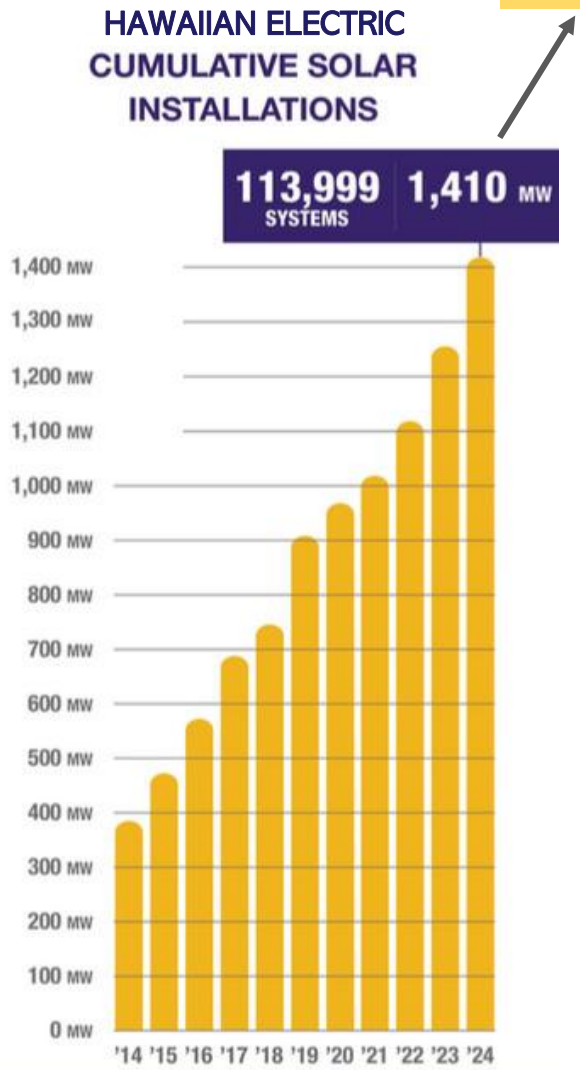
36% Renewable Energy
Renewable Energy Source Breakdown



Utility Scale BESS – 1,617 MWh Installed
(~ 6.5 million kg)

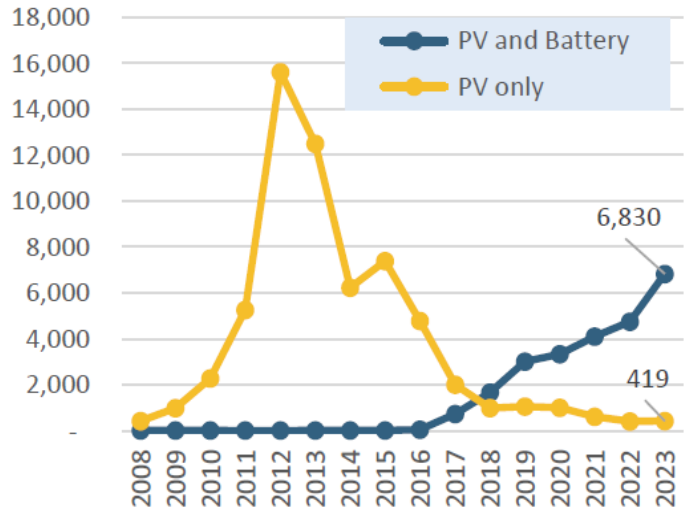
Registered EVs – 37,192 (April 2025)
(~ 9 million kg)

1,410 MW → Over 6 million panels*
(at 1/3 the way to 100% RE)



*Could circle the moon with PV panels placed end-to-end. We need to circle several more times

Number of Permits Issued



More than 25K customer sited BESS installed to date … its the "new normal"
(~1.5 million kg)

Source: Hawaii State Energy Office, DBEDT

Waste Management of End-of-Life Clean Energy Products in Hawaii

By: Dr. Michael Cooney, Hawaii Natural Energy Institute, University of Hawaii (December 2024)

- Hawaii cannot achieve its goal of 100% renewable energy by 2045 absent reliance on substantial investments in ***PV panels*** and ***battery energy storage systems*** (BESS).
- To date, Hawaii imported over ***6 million PV panels*** and approximately ***8 million kilograms of lithium-ion batteries (LIBs)***.
- As this equipment nears end-of-life (EoL), it is expected to increasingly appear in Hawaii's waste streams.
- Waste streams related to these technologies pose significant risk, due to the high cost and sometimes inability to ship them out of the Hawaiian Islands at the end of their useful lives.
- The options for addressing EoL PV panels and LIBs in Hawaii generally include:
  - Shipping them off-island
  - Landfilling
  - Stockpiling
  - Reuse
  - Recycling
  - Extended Producer Responsibility (EPR) laws

Challenges with EoL Options for PV Panels and BESS in Pacific Islands

Shipping

- High costs for:
  - Pretreating
  - Packing
  - Fire suppression
  - Insurance
    - Costs are increasing due in part to increases in undeclared shipments
- Increasingly strict regulations on transport of hazardous materials
- Shippers/ports unwilling to accept cargo (especially EoL, damaged, defective or recalled (DDR) LIBs)
- Hawaii laws/regulations that make it effectively impossible to secure bonding for shipments

Stockpiling

- Explosion, fire and electrical hazards
- Island space limitations

Landfilling

- Laws/regulations barring or complicating disposal of hazardous waste
- High cost to test for hazardous waste
- Facility refusal to accept materials
- Fire/explosion hazard
- Lack of human processing capacity

Reuse/Refurbishment

- Lack of a market for used equipment due to falling prices and improving technology
- Regulatory and interconnection restrictions
- Lack of used equipment in good working order
- Difficulty assessing old equipment
- Lack of standards for quality and performance

Recycling

- Laws/regulations prohibiting crushing, shredding or otherwise treating of equipment that contains hazardous materials
- Lack of operational recycling centers
- High cost of pretreating to remove hazardous materials
- Low value of recovered materials
- Low cost of mining new materials

EPR Laws

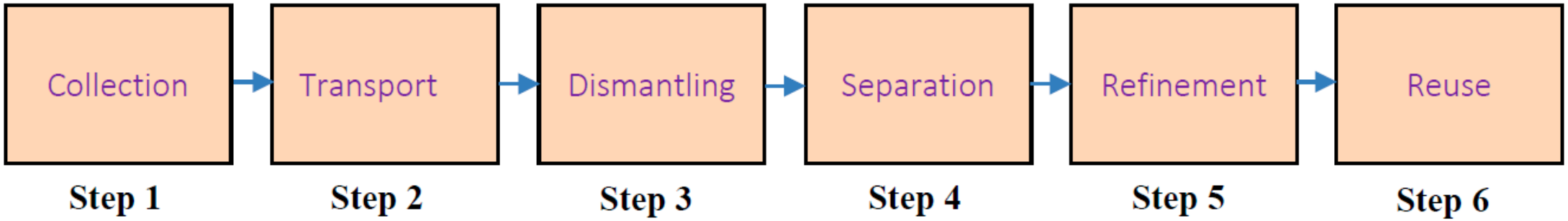
- Risk of manufacturers declining to import
- Difficulty identifying manufacturers and/or enforcing their compliance
- Risk of manufacturer going out of business
- Insufficient market size

PV & Li-ion Battery Waste Management Issues for Hawaii and Pacific Islands

- The recycling pathways for PV panels and LIBs are currently *undependable and costly* for the foreseeable future
  - For example, with respect to LIBs, it is currently less expensive to mine lithium than to recycle it
  - *Lower recycling costs are not expected to occur in the U.S. or Asia in the foreseeable future.*
- PV Panels Disposal
  - Landfilling cost on the U.S. mainland: $1.38 per panels *(Concerns about landfilling PV modules are increasing)*
  - Shipping cost from Hawaii is $15 to $32 per panel, depending on container size
  - Average recycling cost is $28 per panel for recycling in the U.S., if landfilling ceases to be an option
    - Recycling costs as low as $0.75 per panel in Europe (higher volumes and significant government investment)
- LIBs Disposal – *Landfilling of Li-ion batteries is **not** an option*
  - Recycling cost estimated to be $2.20 per kg in the U.S., this Includes ground transport to the facility, labor for disassembly and cost offset by recycled metals
  - The shipping cost from Hawaii for batteries that are not damaged, defective or recalled (DDR) is ~$US 7.70 per kg
  - Ships are either not accepting DDR batteries at all or charging over 7 times more for shipping them in special containers due to their fire risk
    - This is resulting in large stockpiles of DDR batteries on islands or illegal dumping

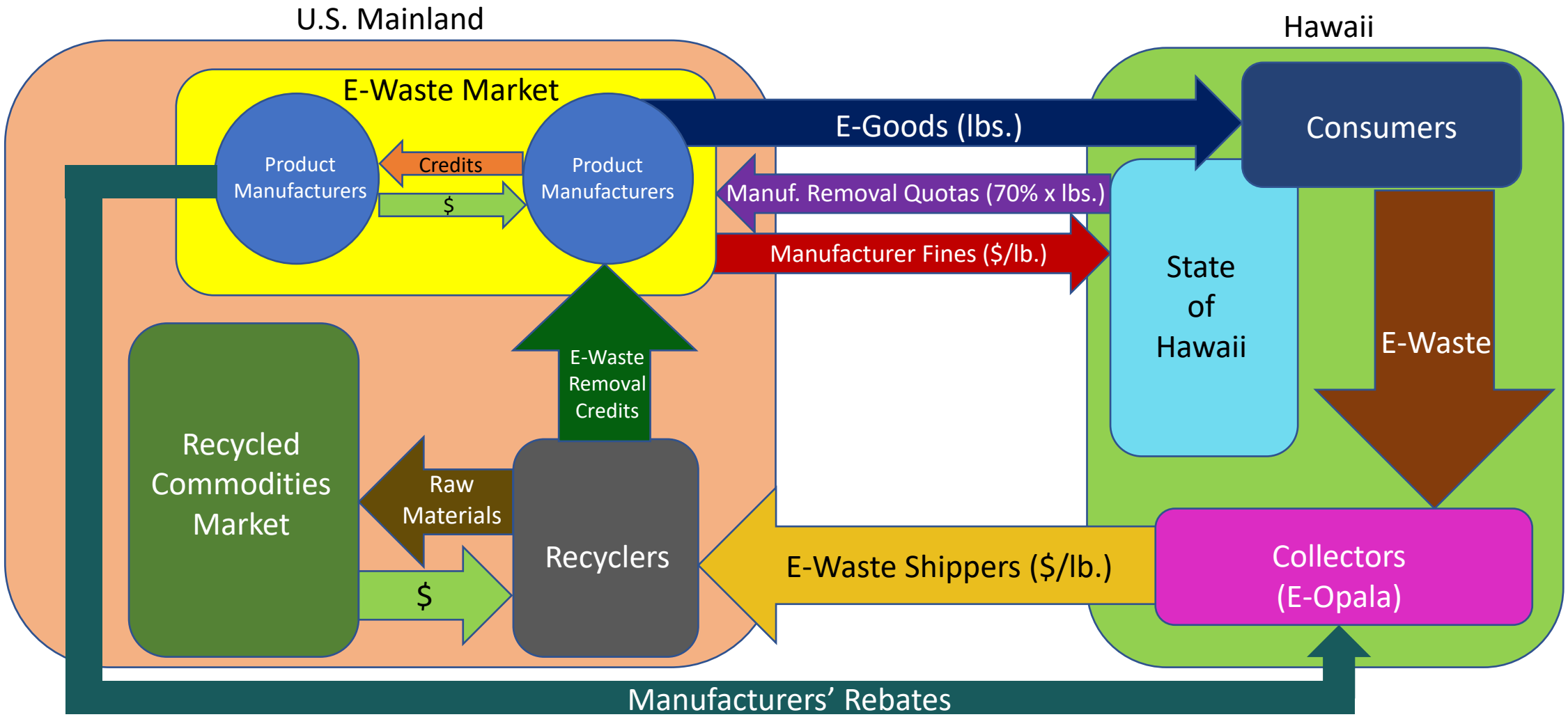
Best Practices

General process flow diagram for end-of-life management of clean energy materials



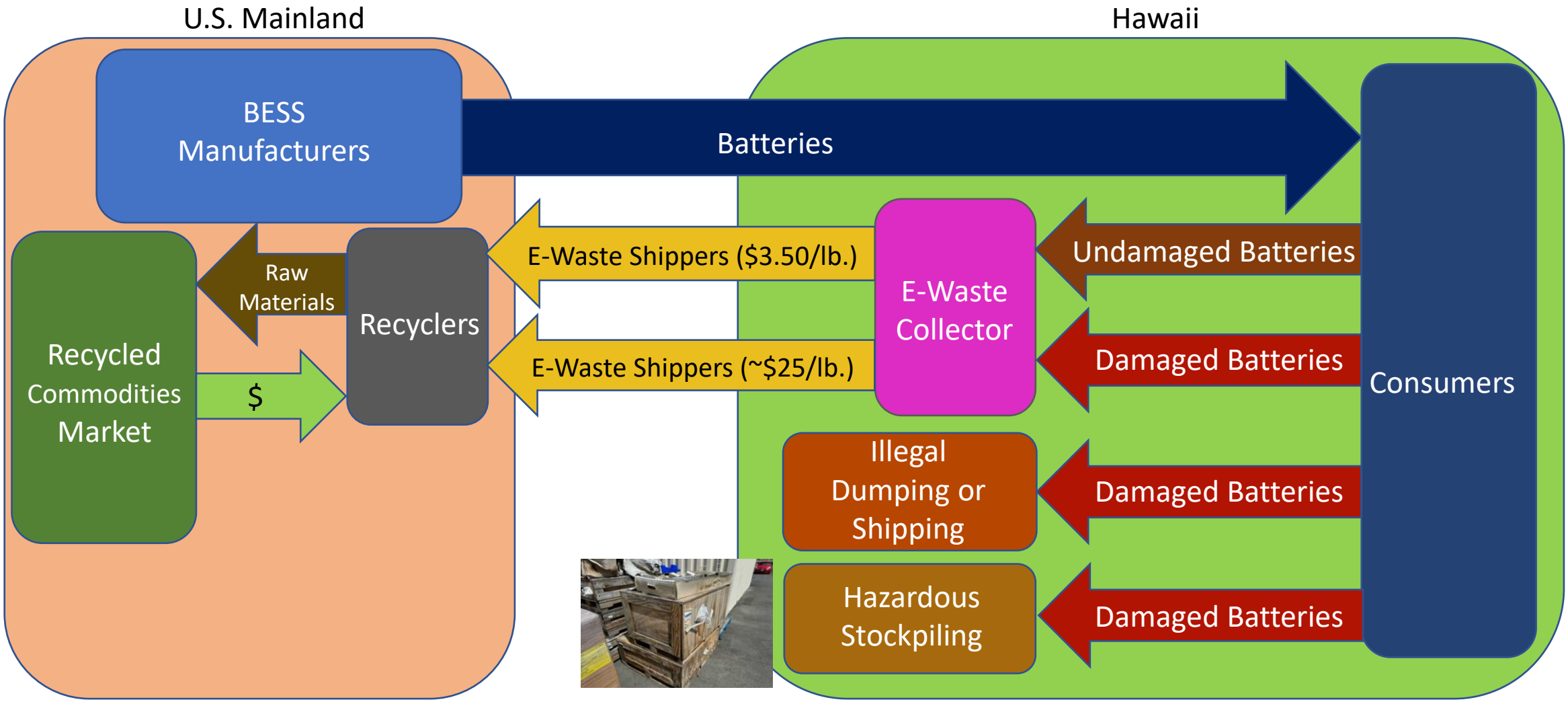
Potential Hawaii Solution for PV Panel Disposal

Applicable today to Non-Hazardous Electronic Devices (can statutory quotas and fines be applied to PV panels?)



Present Battery Disposal Problem in Hawaii

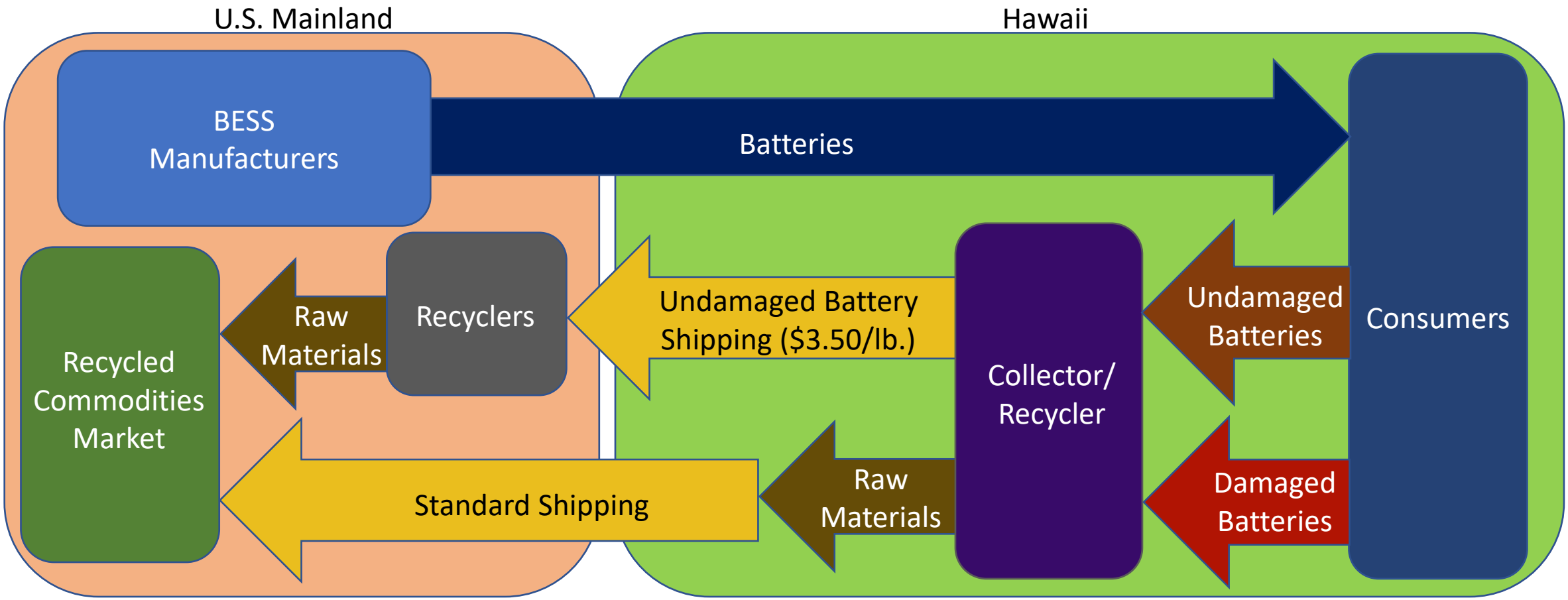
Current Situation (Battery E-Waste that can't be shipped is being stockpiled or illegally landfilled or dumped)



Potential Solution for Battery E-waste in Hawaii

As envisioned by a leading Hawaii E-waste collector

A Hawaiian company has developed a small scale BESS pretreatment facility that could shred deenergized DDR batteries, breaking them down to their safer recyclable components.



RE Waste Recycling

Looking ahead …

In discussions with Hawaii stakeholders, three options have been identified that each partially address the costs of disposal and recycling and reduce illegal disposal:

- **Waste Generator Responsibility (WGR)** - the generator of the waste bears the full cost of off-island disposal and recycling
- **Expanded Producer Responsibility (EPR)** - the manufacturers, distributors, or other responsible parties would be physically and financially responsible for the collection and recycling of their products at their end-of-life stage
- **State Assisted Recycle (SAR)** - the State of Hawai‘i would assist salvagers, contractors, and the counties with the costs of collection and off-island disposal and recycling of PV modules and lithium-ion batteries

Recommendations

In Island Context

To achieve comprehensive and effective disposal and recycling of these waste streams, it is recommended to pursue some combination of all three proposed options.

- Ensure and enforce waste generator responsibility (WGR)
  - It is fair and equitable to expect panel and battery owners, who benefit directly from the use of their clean energy materials, to take responsibility for their disposal. That being said, it is also fair to suggest that some users may not have been appropriately informed of the costs and unique responsibilities associated with their disposal of these materials.
- Pursue and manage EPRs where possible
  - Utility-scale projects will eventually be responsible for the disposal of large-scale amounts of waste at high cost and in those cases where the PPAs were not written with “airtight” end-of-life responsibilities and/or the IPPs are near to or insolvent, the presence of EPRs would be extremely beneficial.
- Implement an Advanced Disposal Fee program (SAR).
  - Currently, county staff manage the small amounts of batteries entering the waste stream by dipping into revenues from vehicle registration fees. Concerns have been raised, however, with how to pay for these costs as the number of batteries increases with time. Advanced disposal fees, for example, could also be used to sponsor amnesty programs that serve to bring in wastes that would otherwise be dumped.

Mahalo!

(Thank you)

For more information, contact:

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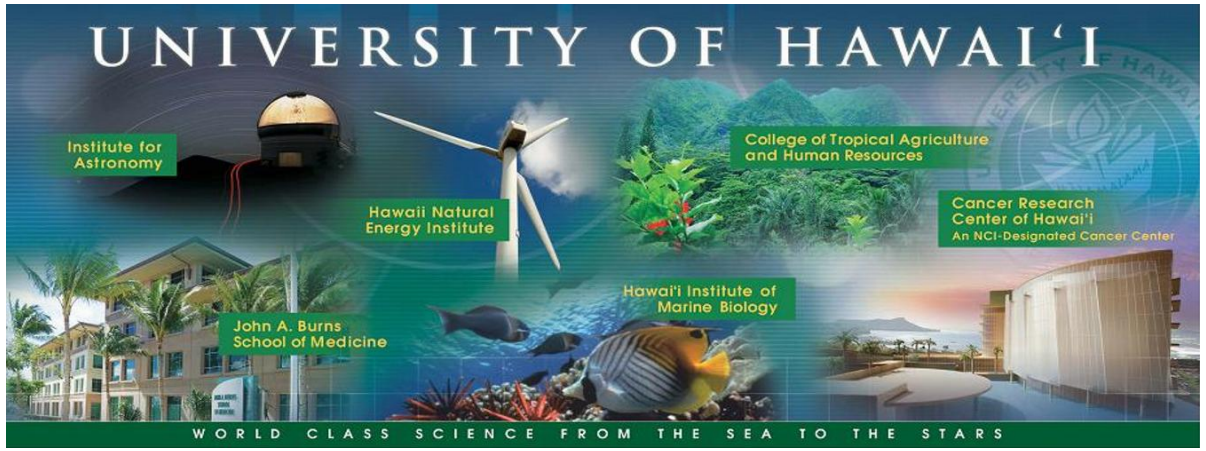
University of Hawai‘i

- Founded in 1907, the ***University of Hawai‘i System*** includes 3 universities and 7 community colleges with approximately 50,000 students.
- ***University of Hawai‘i at Mānoa*** is the flagship campus (the largest and oldest) of the system.
  - 14,576 undergraduate student enrollment
  - 4,680 graduate student enrollment
- ***School of Ocean and Earth Science and Technology (SOEST)*** is the largest research unit on the Mānoa campus.
  - Bring in more than $100 million extramural funding per year



UNIVERSITY of HAWAI‘I SYSTEM

UNIVERSITY of HAWAI‘I MĀNOA

SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI‘I AT MĀNOA

Hawai'i Natural Energy Institute (HNEI)

SOEST, University of Hawai'i at Mānoa

- Organized Research Unit in School of Ocean and Earth Science and Technology (SOEST).
- Founded in 1974, established in Hawai‘i statute in 2007 (HRS 304A-1891).
- Conduct RDT&E to accelerate and facilitate the use of resilient alternative energy technologies and reduce Hawai‘i's dependence on fossil fuels.
- Diverse staff includes engineers, scientists, lawyers, students, postdoctoral fellows, and visiting scholars.

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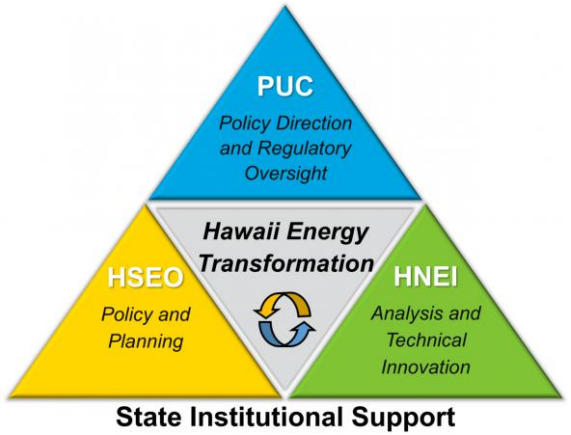

Areas of Focus

- **Grid Integration (Grid*START*)**
- Energy Policy and Analysis
- Electrochemical Power Systems
- Alternative Fuels
- Advanced Materials
- Ocean Energy

Core Functions

- State Energy Policy Support
- Testing and Evaluation
- Education and Capacity Building
- Research and Development
- Modeling and Validation

Grid System Technologies Advanced Research Team (Grid*START*)

HNEI, SOEST, University of Hawai'i at Mānoa

Grid***START*** delivers comprehensive power system solutions through a unique blend of technical expertise and industry insights.

Diverse staff of engineers, lawyers, MBAs, postdoctoral fellows, students, and visiting scholars.

We excel in:

- **Clean Energy Transition**: Integrating renewable energy (RE), developing smart grid technologies, and modernizing power systems to accelerate the low-carbon energy/transportation transition.
- **Scalability**: Addressing challenges across diverse project scales, from grid-edge solutions to grid-wide modeling and analytics.
- **Applied Research**: Bridging the gap between research and real-world applications to solve pressing power grid issues.
- **Regional and Global Impact**: Providing specialized technical support, energy policy and regulatory guidance and energy sector advisory services and training with a focus on the Asia-Pacific region.

Lead for many public-private demonstration projects.

Established to develop and test advanced grid architectures, new technologies and methods for effective integration of renewable energy resources, power system optimization and resilience, and enabling policies and regulations.

Expertise & Focus:

- Energy Policy and Regulation
- Clean Energy Transition Technology Solutions
- Power Systems Planning
- Power Systems Operation
- RE Resource Procurement
- Energy Sector Capacity Building
- Project Management and Execution

Grid*START* Core Team Members, Sponsors, and Partners

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* Prior electric utility company senior management

Sampling of Sponsors & Partners

Team members combine for 75+ years of utility and regulatory experience

Leon R Roose

Chief Technologist

Mr. Roose is a tenured faculty member of the Hawai‘i Natural Energy Institute (HNEI), University of Hawai‘i at Mānoa, where he formed and has led for over a decade HNEI’s Grid***START*** (Grid System Technologies Advanced Research Team), a team of professionals focused on energy transition enabling policy and regulation, advanced grid architectures, grid modernization technologies, and novel methods to achieve reliable grid integration of RE resources, power system optimization and energy resilience goals.

He served in numerous leadership roles at the Hawaiian Electric Company for 19 years prior including management of renewable energy planning and integration, generation resource planning and competitive procurement, negotiation and administration of all power purchase agreements for the utility, transmission and distribution system planning, smart grid planning and projects, system relaying and protection, and fuel purchase and supply to all utility generating plants. He is a licensed attorney, formerly in private law practice in Hawai‘i and served as Associate General Counsel at Hawaiian Electric. He holds a B.S. in Electrical Engineering and a J.D. from the University of Hawai‘i at Mānoa.