

**NET
ZERO
WORLD
INITIATIVE**

Accelerating Global
Energy System
Decarbonization

US-Singapore Study on Regional Connectivity – Phase 1 Results

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Net Zero World

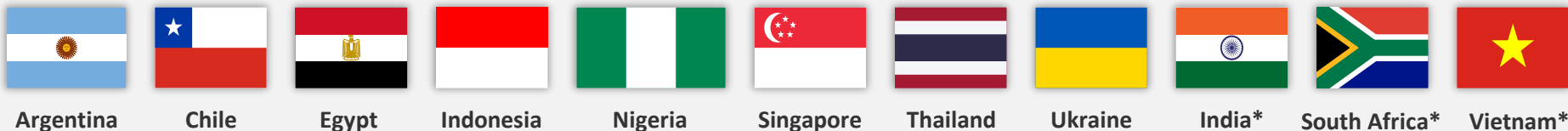
A cross-lab team that partners with countries to provide demand-driven support:

- 1** Rigorous country-driven net-zero pathways and technical and investment plans
- 2** World-class technical support for transformative implementation and just transition actions
- 3** Investment mobilization assistance at all stages.

Leveraging Deep Expertise of 10 DOE National Labs to Drive Decarbonization Efforts



Partner and Affiliated* Countries



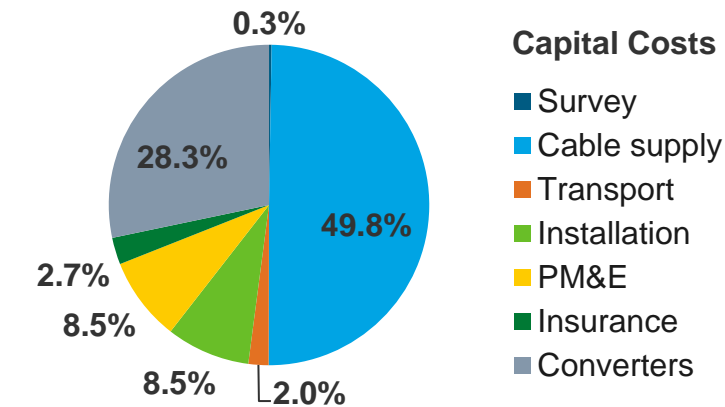
Estimated System Costs

Approach

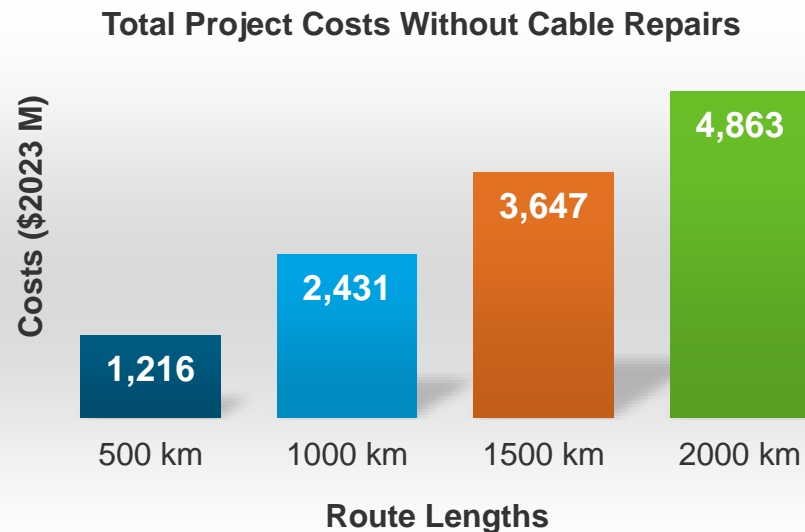
- Present value (2023) from 25-year cash flow
- Allows for sensitivities on cable repair assumptions, length, CAPEX inputs

Key assumptions

- Weighted Average Cost of Capital (WACC): 7%
- 25-year cable lifetime
- 2 x 1.2 GW HVDC subsea bipole cables
- HVDC converter costs (MISO 2024)



PM&E - Protection, Mitigation, and Enhancement



Subsea Interconnector Risks and Mitigations

Summary Findings

- High-level external threats identified for interconnector: turbidity flows, scouring currents, crossings, fishing, anchors.
- Review of failure statistics - recent power cables have lower proportion of external faults, compared to telecoms and older cables. Suggests (1) burial and other mitigations work well; (2) improved insulation and cable quality may be required
- General repair time: 65-90 days across failure modes.
- Cable burial depth: case-by-case based on Cable Burial Risk Assessment, generally 0.5-3 m.
- Horizontal separations: case-by-case, generally 3x water depth or 500 m. Vertical separation at crossings: 300 mm; various point protections possible.

Annual ship tracks in SE Asia (2013)



Halpern, B., et al. (2015). Cumulative human impacts on marine ecosystems (2008 and 2013). The Knowledge Network for Biocomplexity Repository. [doi:10.5063/F1S180FS](https://doi.org/10.5063/F1S180FS)

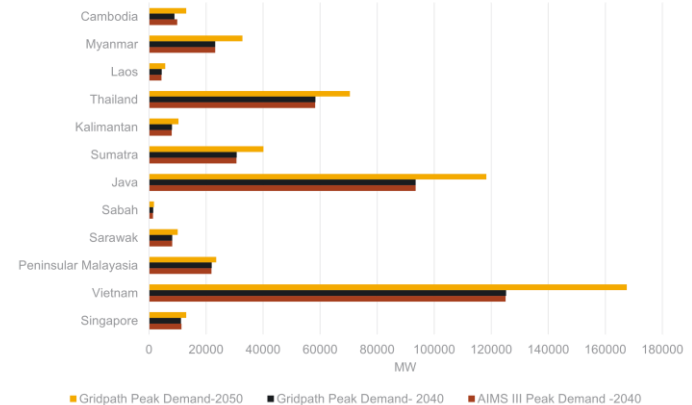
Modeled 3 Scenarios in GridPATH

- An *open-source* capacity expansion model of ASEAN* has been developed by the Net Zero World team, leveraging prior work in the region, national power sector planning, technology costs, and renewable energy resource potential and evaluated 3 scenarios Baseline, Singapore Net-Zero, Baseline (Restricted Transmission)
- Initial results indicate cost savings of several \$B across ASEAN

Figure. Nodes in Southeast Asia for Analysis



Figure. Peak Demand in AIMS III Study Compared to GridPath Model (Used in this Analysis)



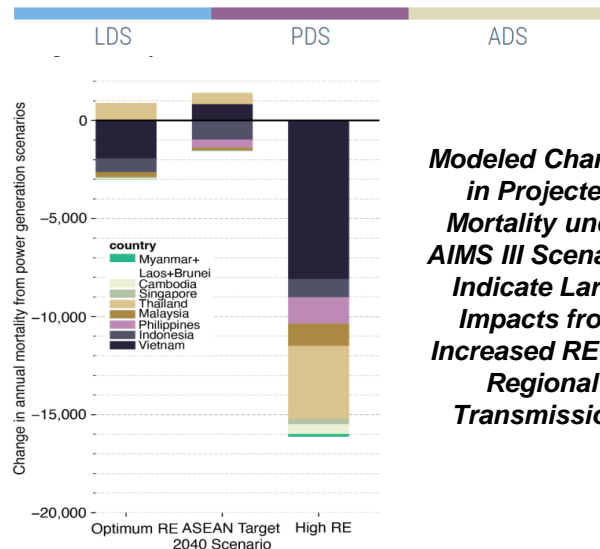
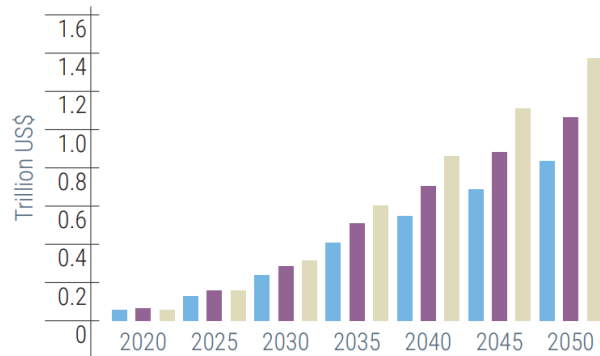
Employment Estimates Related to Subsea Interconnector (from Stefek et al.)

| Job Category | Average Employment (FTE/Year)* | Qualifications Required of Work Force |
|---|--|---|
| Maritime Construction: vessel crew to install subsea cable and wind turbines | 500 – 2,100 | Majority of roles require a Bachelor's degree and/or specialized training |
| Export Cable Manufacturing: workers for producing subsea export cable | 650 – 2,600 | Minimum of GED or high-school diploma for factory roles; Bachelor's degree required for safety and oversight roles |
| OSW Substation Manufacturing: workers for building substation the enables transmission to onshore grid | 40 – 100 | GED or high school diploma for rolling, welding, and coating roles; specialized training for technicians; advanced degrees for oversight roles |
| Port and Staging: includes terminal crews and portside logistics and management | 400 – 1,600 | No requirements for laborers; port and terminal crew generally require minimum GED or high school diploma and/or specialized training; management roles require minimum of an Associate or Bachelors degree |
| Operations and Maintenance: long-term operations and maintenance (wind technicians, plant managers) | 100 – 500 (2024) 600 – 2,300 (2030) | Marine crew requires GED or high school diploma; more senior roles require Associates degree; other wind plant roles require specialized training and/or Bachelor's degree |

Socio-economic benefits of regional interconnection are significant

- **Significant** energy sector **investment** and economic growth across ASEAN. By 2050:
 - **\$2 billion** in annual R&D investment.
 - Cumulative electricity generation capacity investment of **\$1.4 trillion**.
 - **Local industry development** through improved power generation, resource optimization, and reduced generation costs.
 - Regional **clean energy supply chain**
- **2000-9000** direct annual **jobs** created
- **Reduced** electricity **costs** regionally by **3-3.9%**
- **Increased GDP** by **0.8-4.6%** per country
- Reduced **financial risk** and increases **energy access**
- Improved system **reliability** and **resilience** to weather event
- Reduce particulate air **pollution** for **99%** of population by average of **50%**, leading to **15,000** fewer pollution-induced deaths annually

Total Power Supply Investment Reaches \$1.4 trillion by 2050.



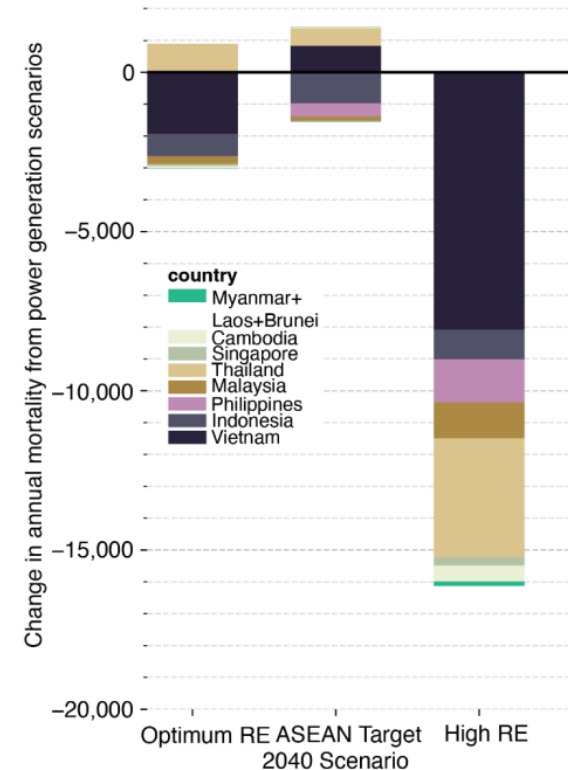
Modeled Changes in Projected Mortality under AIMS III Scenarios Indicate Large Impacts from Increased RE and Regional Transmission.

Air Quality and Public Health

- The energy sector's contribution to air pollution caused mortality is 5th highest in Southeast Asia
- All alternative AIMS III RE and interconnection scenarios lead to a decrease in regional, net PM_{2.5}-caused annual mortality relative to the base scenario in 2040.

Modeled Changes in Projected Mortality under AIMS III Scenarios

Change in mortality relative to 2040 Base Scenario



Source: Clack, Goggin, and Choukulkar (2020); Klimont (2023); Ravi et al. (2023)

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Thank You

Net Zero World Initiative
National Renewable Energy Laboratory (NREL)
Pacific Northwest National Laboratory (PNNL)



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