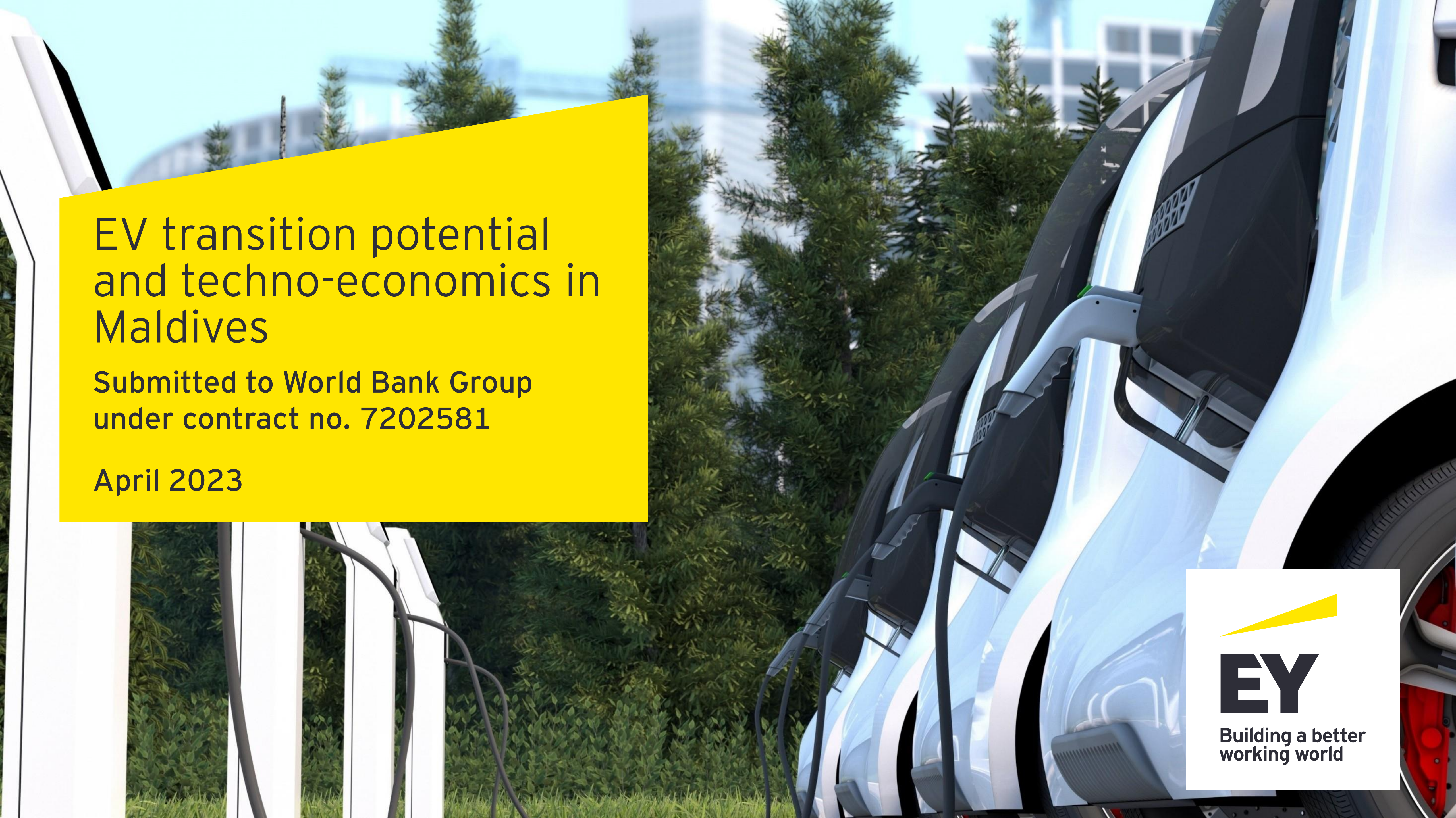


EV transition potential and techno-economics in Maldives

Submitted to World Bank Group under contract no. 7202581

April 2023

EY

Building a better working world

Objectives and key stakeholders

Kick off in August 2021

Power sector analysis for VRE and EV integration

- Load Forecast and Network Analysis
- Least Cost Generation Expansion
- Operational Simulation - Dispatch Analysis
- Capacity Impact of EV Load on Network

Assessment of Electric Mobility Potential

- Techno-economics of EV transition
- Potential adoption scenarios
- Policy framework & financing strategy
  - ❖**Electric bus**
  - ❖**Solar electric ferries**
  - ❖**Diesel-electric hybrid ferries**
  - ❖**Micro-mobility**
  - ❖**Grid impact**
  - ❖**Public EV charging infrastructure**
  - ❖**Battery swapping**
  - ❖**Rooftop PV generation for EV charging**

Scenario planning to achieve Net Zero by 2030

- Scenario modelling with baseline and RE capacity additions through 2030

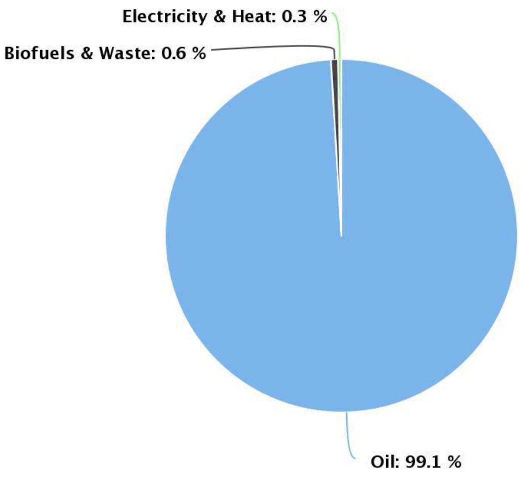
Stakeholder	Engagement role
World Bank Group	SRMI – ASPIRE – ARISE
Ministry of Environment, Climate Change and Technology (MECCT)	Nodal agency for WBG investment plans
Maldives Transport and Contracting Company (MTCC)	Public transport services – buses, ferries etc.
STELCO	State owned integrated utility providing energy services in greater Male region
FENAKA	State owned integrated utility providing energy services in Addu

Background: Maldives primary energy mix and sectoral breakdown of GHG emissions

- Updated Maldives NDC (2020) aims to reach net-zero by 2030 with support and assistance from the international community
- Transportation and electricity generation accounted for 60% and 34% of energy use vis-à-vis emissions respectively in 2019
- Renewable power generation, energy storage and electric mobility are the principal pathways for achieving net-zero emissions in Maldives

Total Energy Supply by Fuel. Year: 2019

Unit: Terajoules

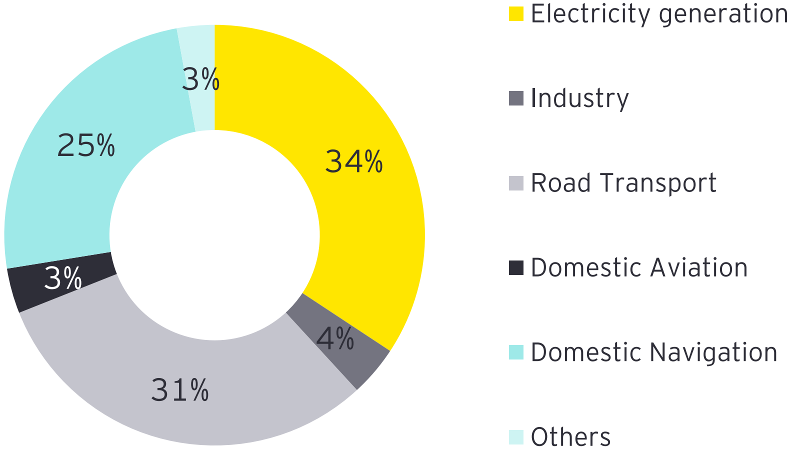


Source: UNSD

Retail price of electricity	Min. (USD / kWh)	Max. (USD / kWh)
Domestic	0.10	0.28
Commercial	0.21	0.43
Government Institutions	0.21	0.28
Solar PPA price	~0.10 (ASPIRE)	

Source: STELCO; 1 MVR = 0.065 USD; World Bank

Energy use vis-à-vis emissions in Maldives 2019



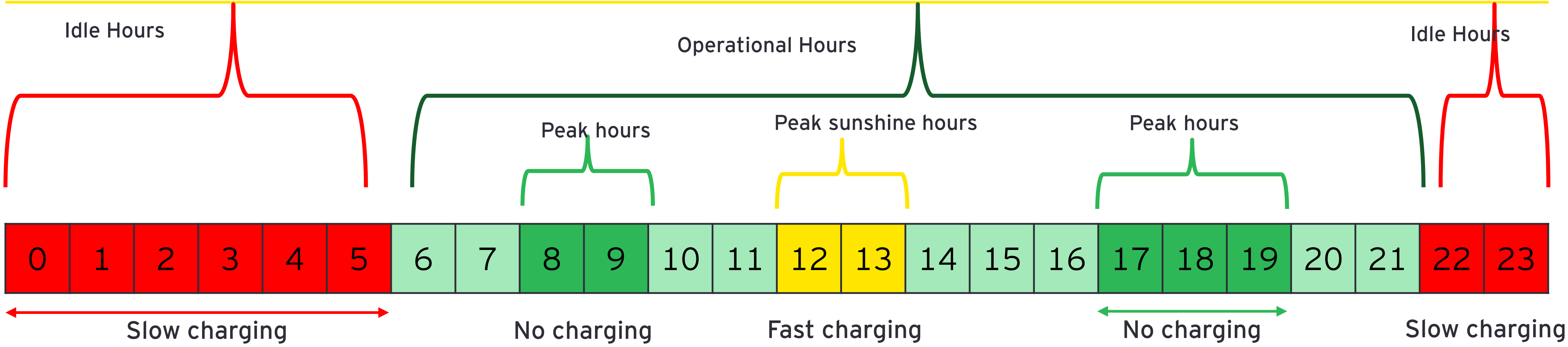
Source: UNSD

Summary: Financing potential for supporting EV transition in Maldives

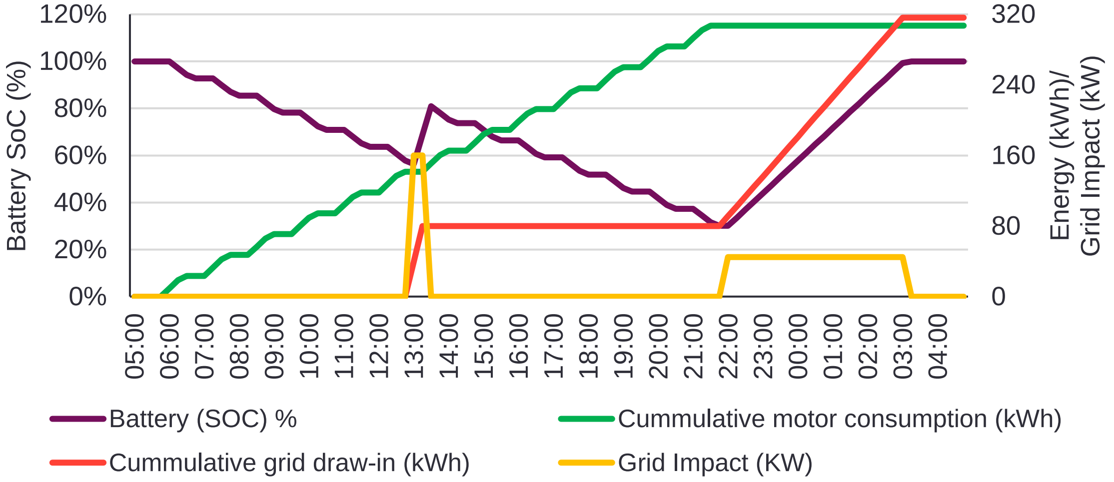
- Integrated approach towards EV and energy transition investments will drive long term value and net-zero emissions

Item	Unit	Solar electric ferries	Diesel electric Hybrid ferries	Electric buses	Rooftop PV generation at MTCC terminals	Micro-mobility pilot
Fleet size	No.	13	3	53		300 electric bikes
No. of routes	No.	3	3	12		15 hubs
Solar PV installed capacity for zero emission operations	kWp	1307	94	1763	776	
Loan component	USD Million	9.77	1.10	12.08	0.94	0.69
Subsidy/grant component	USD Million	1.29	0.13	4.79		
Total investment potential	USD Million	**11.07**	**1.23**	**16.87**	**0.94**	**0.69**

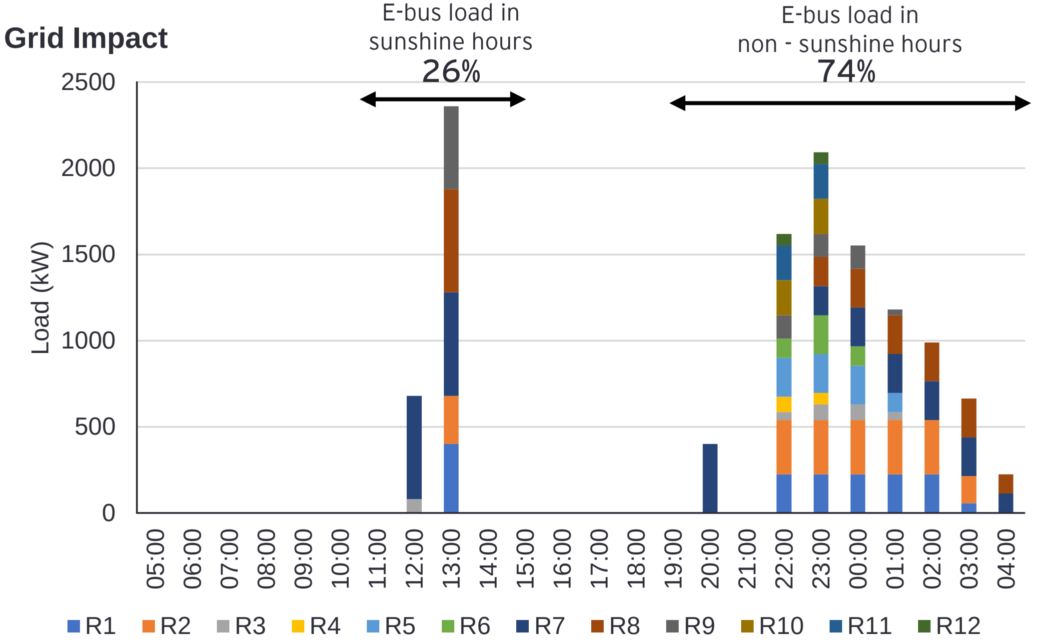
1. Key findings and learnings for SIDS: Charging strategy for public EV fleets must ensure minimum disruption in operations and minimum curtailment of peak solar generation



E-bus charging profile for Route 1: Carnival (Male') – Hulhumale



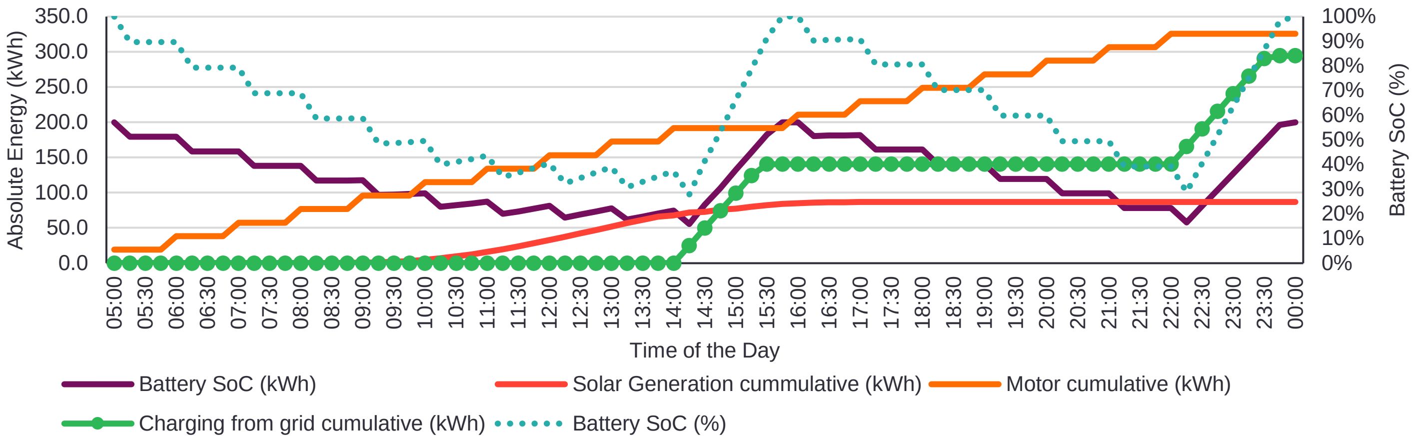
Grid Impact



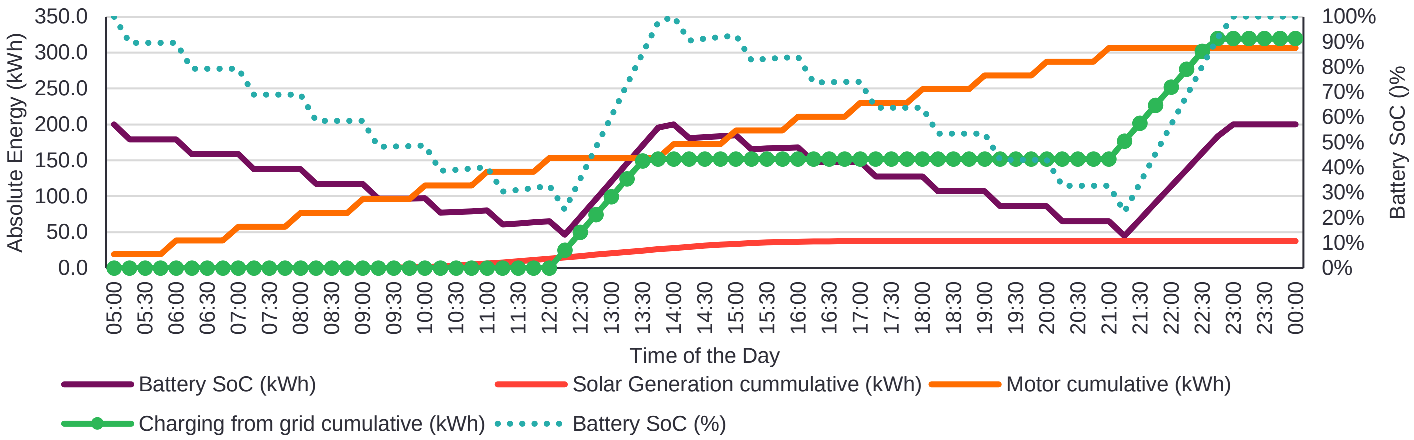
2. Key findings and learnings for SIDS: Techno-economics must consider route specific attributes to derive energy profile and technical design parameters for EV transition planning

	Values	Unit
Route	**Male - Villingili**	-
Trip length	**3.35**	**km**
Total trips/ferry	**17**	**#**
Speed of E-ferry	**18.5**	**km/hr**
Trip time	**11**	**min**
Docking time	**variable**	**min**
Motor power	**106**	**kW**
LFP Battery capacity	**200**	**kWh**
Generation by Solar PV on average solar day	**86.7 (23%)**	**kWh/day**
Generation by Solar PV on low solar day	**37.5 (10%)**	**kWh/day**
Avg. energy per trip	**17 - 19**	**kWh/trip**
Grid energy requirement on average solar day	**294**	**kWh**
Grid energy requirement on low solar day	**320**	**kWh**
LFP Battery C-rating	**0.5**	**C**
LFP Battery Round trip efficiency	**85%**	**%**
Lower SoC limit	**20%**	**%**
LFP Battery energy density	**100**	**Wh/kg**

Average solar generation Route-2

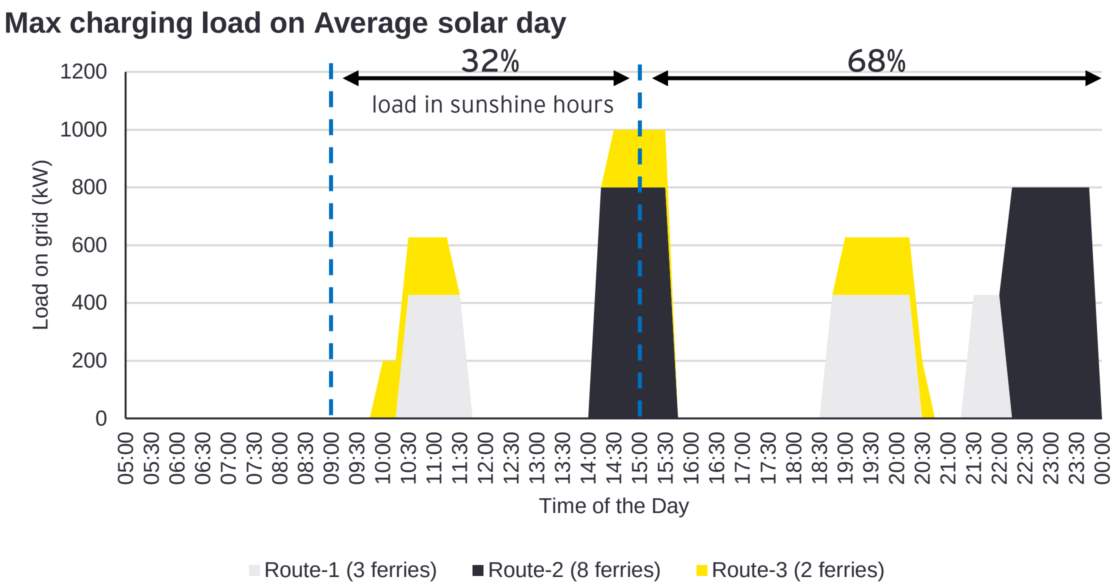


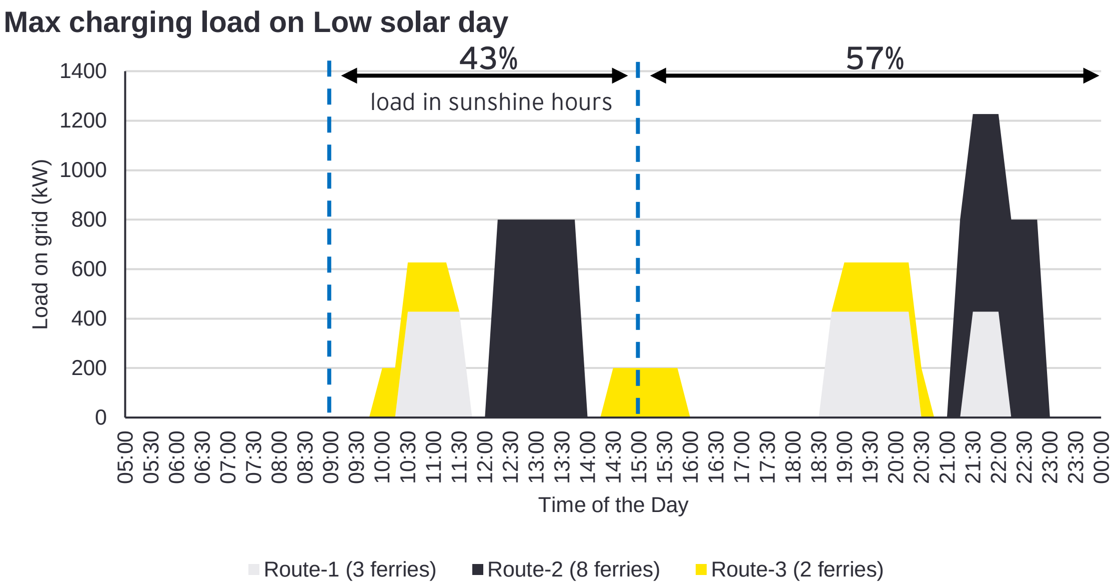
Low solar generation Route-2



NOTE: Battery annual charge/discharge cycles: 730

3. Key findings and learnings for SIDS: Grid impact from charging solar electric ferries is a factor of daily total distance travelled and solar resource availability

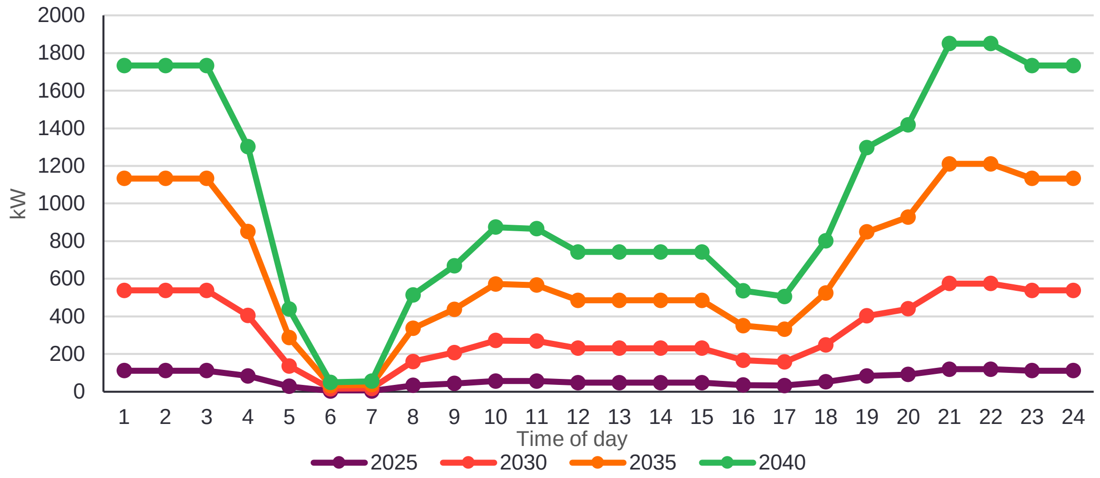




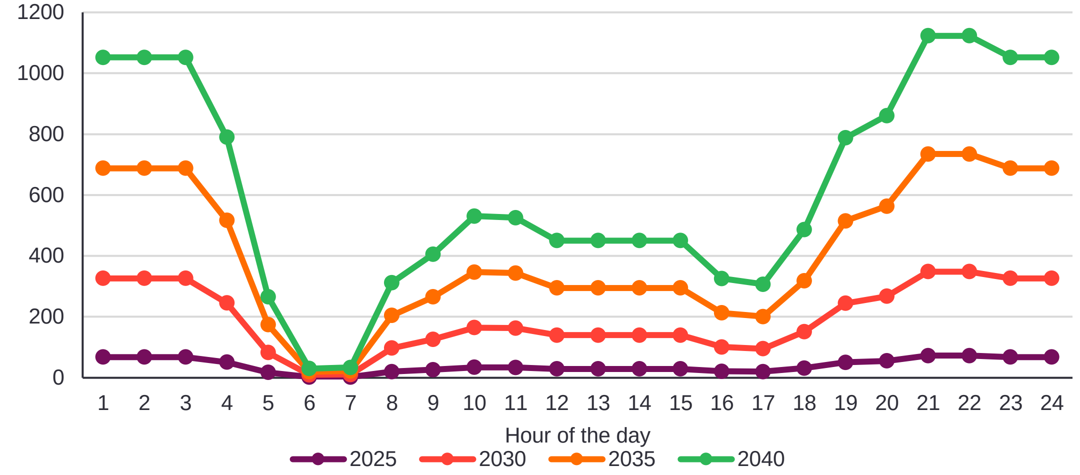
	Route-1	Route-2	Route-3	Total
Total Ferries	3	8	2	13
Total annual grid energy (kWh)	5,29,769	9,15,255	3,11,908	17,56,932
Peak load on grid (kW)	428	800	200	1,228
Solar DC capacity required to meet the excess demand (kW)	332	574	196	1,102

4. Key findings and learnings for SIDS: Coordinated charging induced from time-of-day tariff incentives can help optimise battery storage requirement in power system capacity expansion

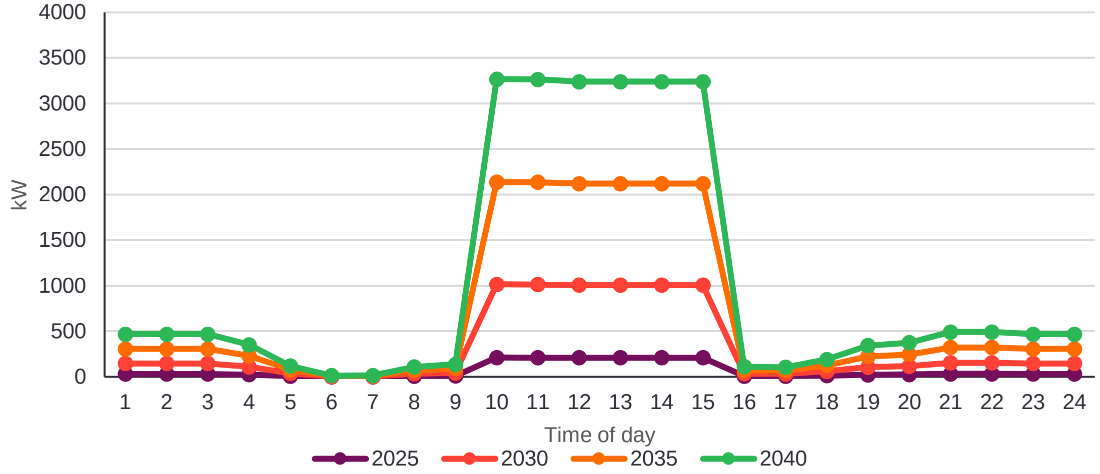
Greater Male: BAU case dominated by home charging



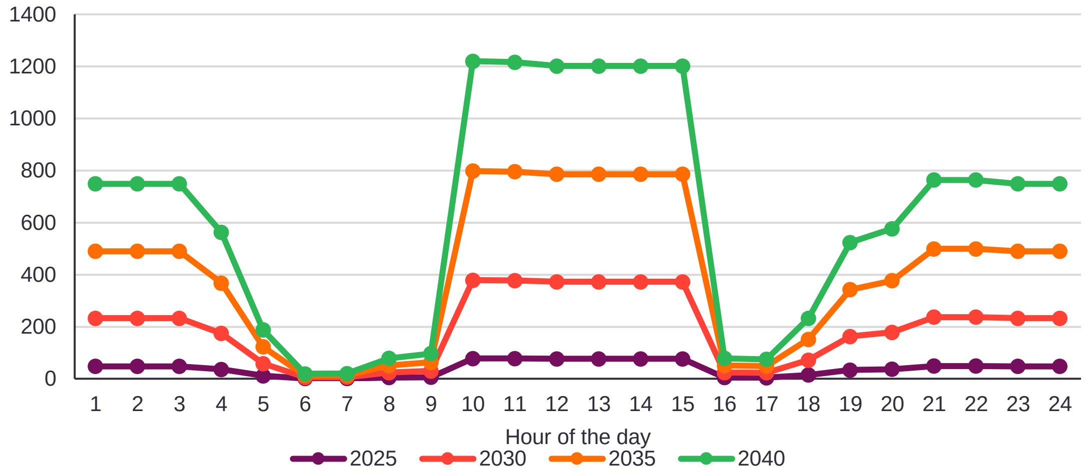
Addu: BAU case dominated by home charging



Greater Male: Coordinated case dominated by public charging

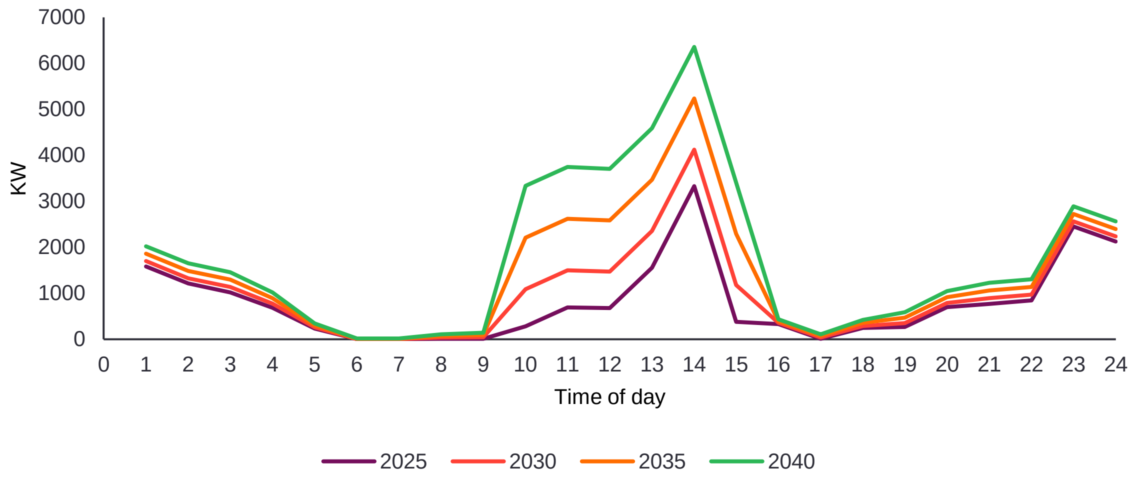


Addu: Coordinated case dominated by Public charging

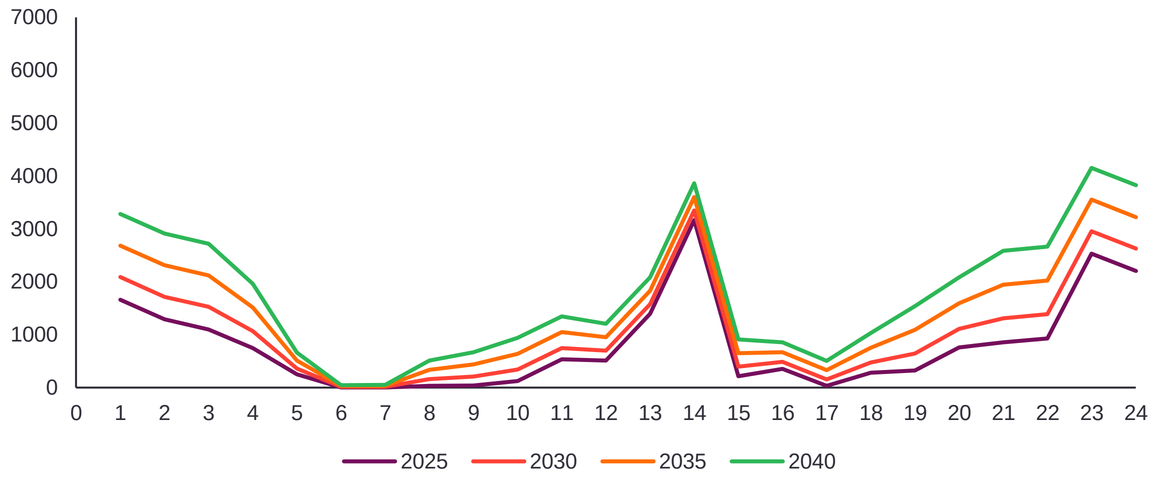


5. Key findings and learnings for SIDS: Cumulative grid impact from EV transition planning in Greater Male and Addu grids

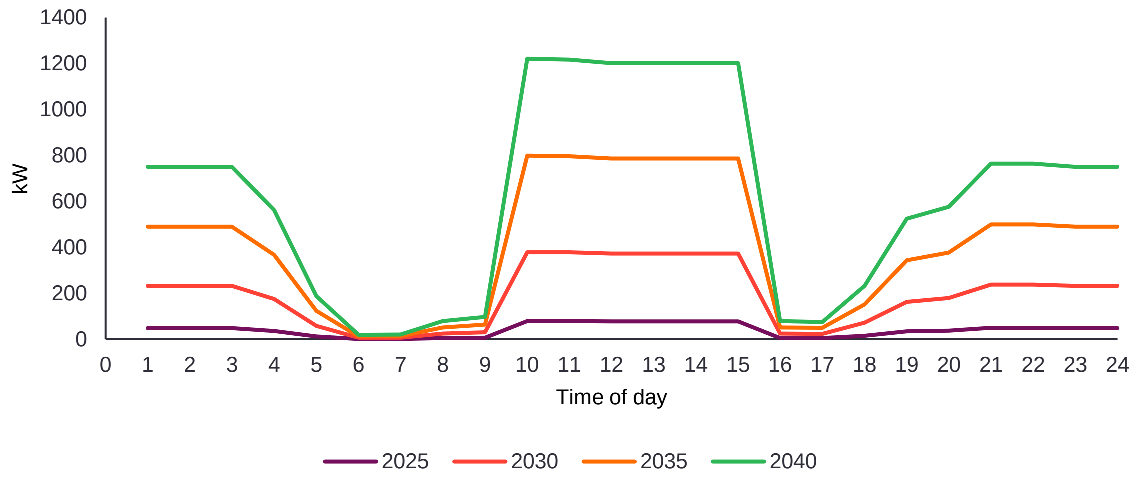
Total grid load on Greater Male - Coordinated charging



Total grid load on Greater Male - UnCoordinated charging



Total grid load on Addu - Coordinated charging



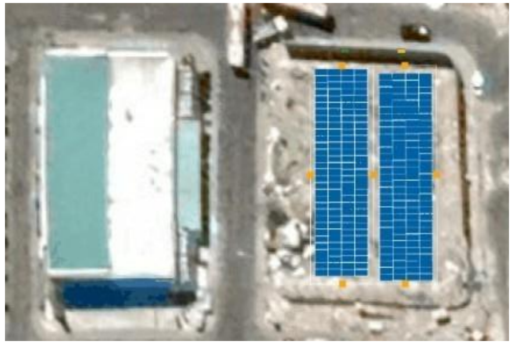
Total grid load on Addu - UnCoordinated charging

6. Key findings and learnings for SIDS: Rooftop PV generation at bus/ferry terminals can support affordable access to renewable energy for EV fleet charging

MTCC Site description	AC capacity (kWp)	Annual Generation Potential (Million kWh)
Keyligematha Bus Terminal	60	0.11
Henveyru Ferry Terminal	100	0.20
Hulhumale Ferry Terminal	150	0.26
Mafaanu Bus terminal	120	0.22
Mafaanu Ferry Terminal	40	0.08
Minibus Parking	120	0.22
Thilafushi Ferry Terminal	30	0.05
Villingili Ferry Terminal	50	0.10
Total	**670**	**1.25**

- Access to affordable round the clock solar / hybrid electricity is fundamental to accelerated zero-emission EV transition
- Grid banking of solar power generation can complement any coincidence mismatch in PV generation and EV charging patterns

6. Minibus Parking Design Studio (thesolarlabs.com)



2. Henveyru Ferry Terminal

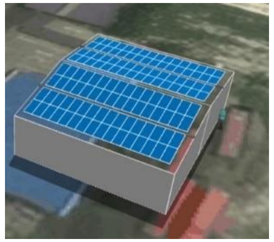
Design Studio (thesolarlabs.com

7. Thilafushi Ferry Terminal

Design Studio (thesolarlabs.com)

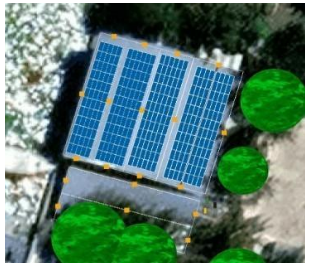
1. Keyligematha Site

Design Studio (thesolarlabs.com)



3. Hulhumale Ferry Terminal

Design Studio (thesolarlabs.com)



4. Mafaanu Bus Terminal

Design Studio (thesolarlabs.com)

5. Mafaanu Ferry Terminal

Design Studio (thesolarlabs.com)

8. Viligilli Ferry Terminal

Design Studio (thesolarlabs.com)

EY

Ernst & Young LLP

EY | Building a better working world

EY exists to build a better working world, helping to create long-term value for clients, people and society and build trust in the capital markets.

Enabled by data and technology, diverse EY teams in over 150 countries provide trust through assurance and help clients grow, transform and operate.

Working across assurance, consulting, law, strategy, tax and transactions, EY teams ask better questions to find new answers for the complex issues facing our world today.

EY refers to the global organization, and may refer to one or more, of the member firms of Ernst & Young Global Limited, each of which is a separate legal entity. Ernst & Young Global Limited, a UK company limited by guarantee, does not provide services to clients. Information about how EY collects and uses personal data and a description of the rights individuals have under data protection legislation are available via ey.com/privacy. EYG member firms do not practice law where prohibited by local laws. For more information about our organization, please visit ey.com.

Ernst & Young LLP is a Limited Liability Partnership, registered under the Limited Liability Partnership Act, 2008 in India, having its registered office at 22 Camac Street, 3rd Floor, Block C, Kolkata – 700016

ey.com/en_in

@EY_India EY EY India EY Careers India @ey_indiacareers