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The Lebanese Foundation *for* Renewable Energy

Lebanon's Electricity Sector – Leapfrogging to Higher Penetration of Renewables

May 3rd, 2019

Disclaimer

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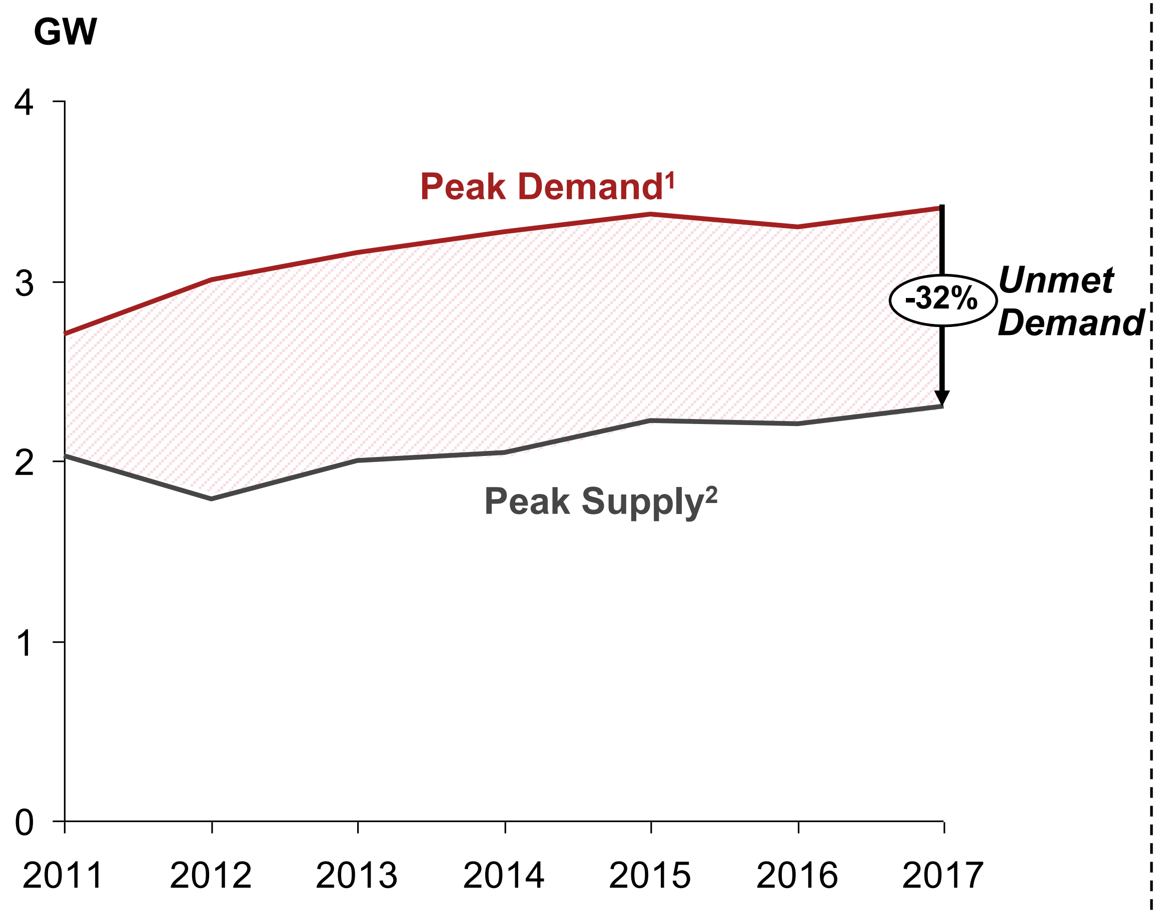
Agenda

Let's get started

1 Overview of the changing context

Lebanon's electricity sector suffers from chronic supply shortages and is a drag on its public finances and economy

Electricity Peak Supply-Demand Balance



Impact on Public Finances and Economy

$36 Bn of Public Debt *(including interest)*
Between 1992-2017, directly attributed to Electricity Sector

$1.4 Bn Annual Subsidy
In 2018, due to mismatch between tariff and cost to serve

Significant Outflow of Foreign Currency
$ ~1.3 Bn / year to cover fuel imports bills

High Electricity Bill on Consumers
High share of inefficient distributed diesel generation

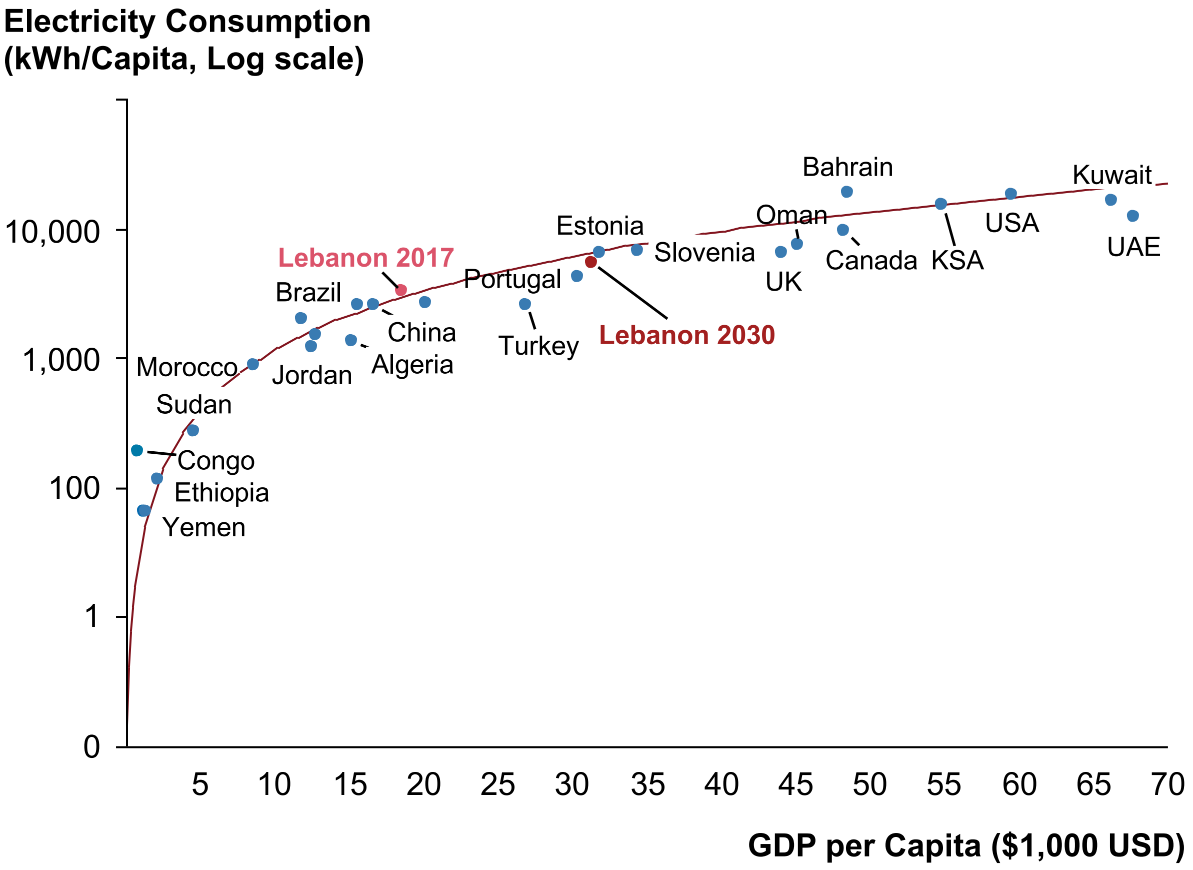
Power Cuts up to 12 Hrs/day
Outside of Beirut, and up to 4 Hrs/day in Beirut

High levels of pollution
From liquid-based utility and distributed generation

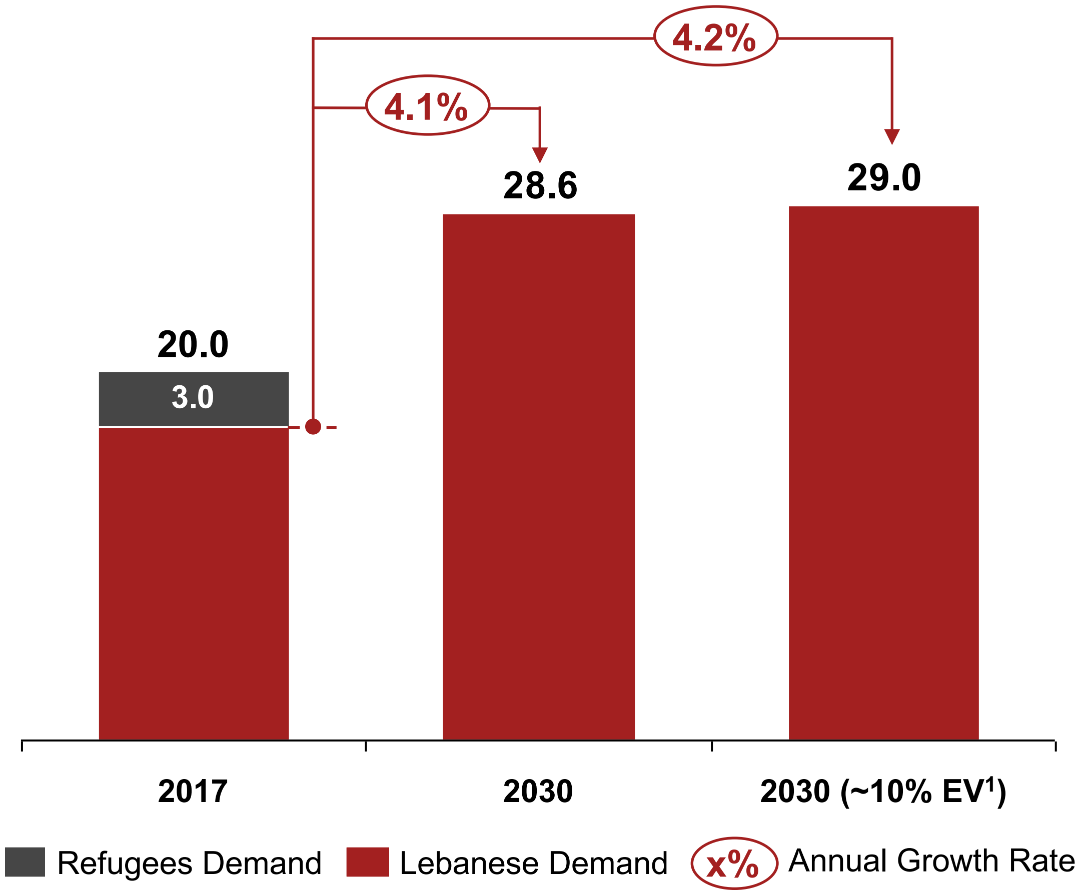
1) Excludes generation and system losses; 2) Excludes private diesel generators supply
Source: MoEW, BlomInvest, Issam Fares Institute, Team Analysis

Demand is set to grow, exacerbating the deficit if no action is taken on the supply side

Electricity Consumption vs. GDP per Capita
2017



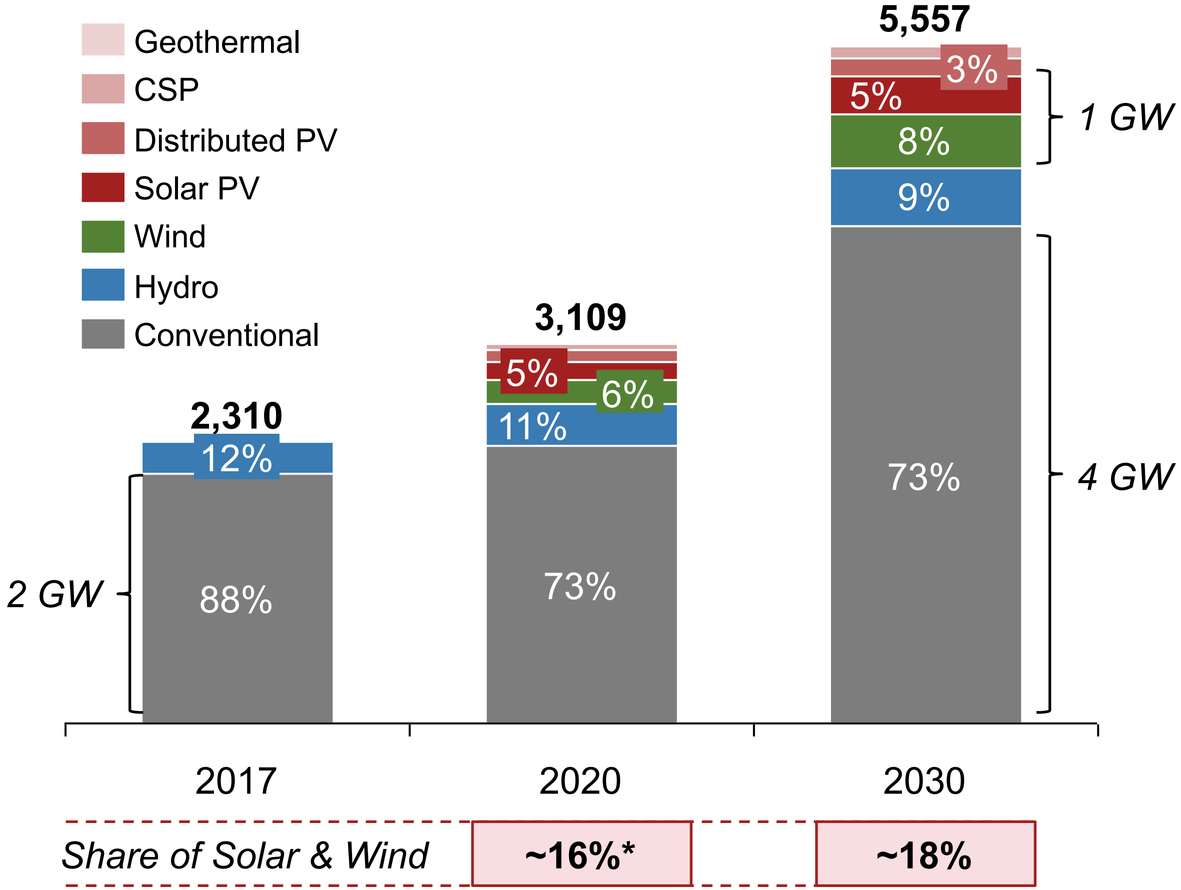
Electricity Consumption[2]
TWh per year



Note: Assuming real GDP yearly growth rate equal to 5.0% as per Lebanon's Economic vision; Real demand is could be lower, in line with recent projections of GDP growth for Lebanon by the IMF
1) Represents ~200,000 EV vehicles; 2) Accounts for 6.1 Mn in-country residents in 2017 (including refugees) and 5.4 Mn in 2030
Sources: World Bank, Lebanon Economic Vision Report, Team Analysis

To close the demand gap, CIP put forward a plan that doubles conventional capacity and installs ~1 GW of solar and wind

CIP 2030 Plan
MW



Solar

300 MW of large-scale solar capacity installed across 3 sites, 150 MW of distributed PV and 100 MW of CSP

Wind

Two 60 MW wind farms in Akkar and ~300 MW spread on various plots across the country

Conventional

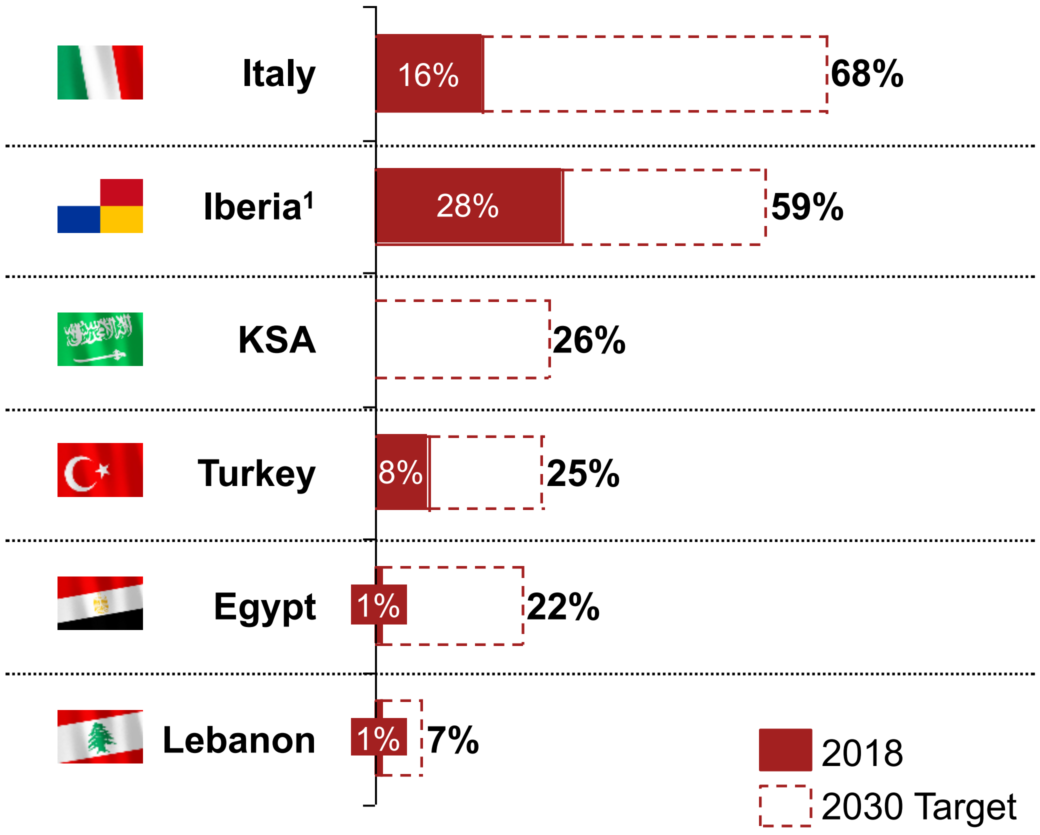
Double capacity by installing six EPC plants of 500 MW each (Jiye, Zouk, Salaata II, Deir Ammar II, and 2 undefined) and two 500 MW IPPs (Salaata I & Zahrani II)

Note 1: On November 6th 2018, Lebanon's prime minister announced a renewable energy target of 30% out of the nation's 2030 electricity and heat mix
Note 2: LCEC issued a 100 MW solar PV tender in May 2017 and released an EoI for up to 300 MW solar PV with storage in April 2018
*) This target may not be met by 2020 based on current delays
Source: Capital Investment Program (CIP), MoEW Renewable Energy Plan, LCEC, Team Analysis

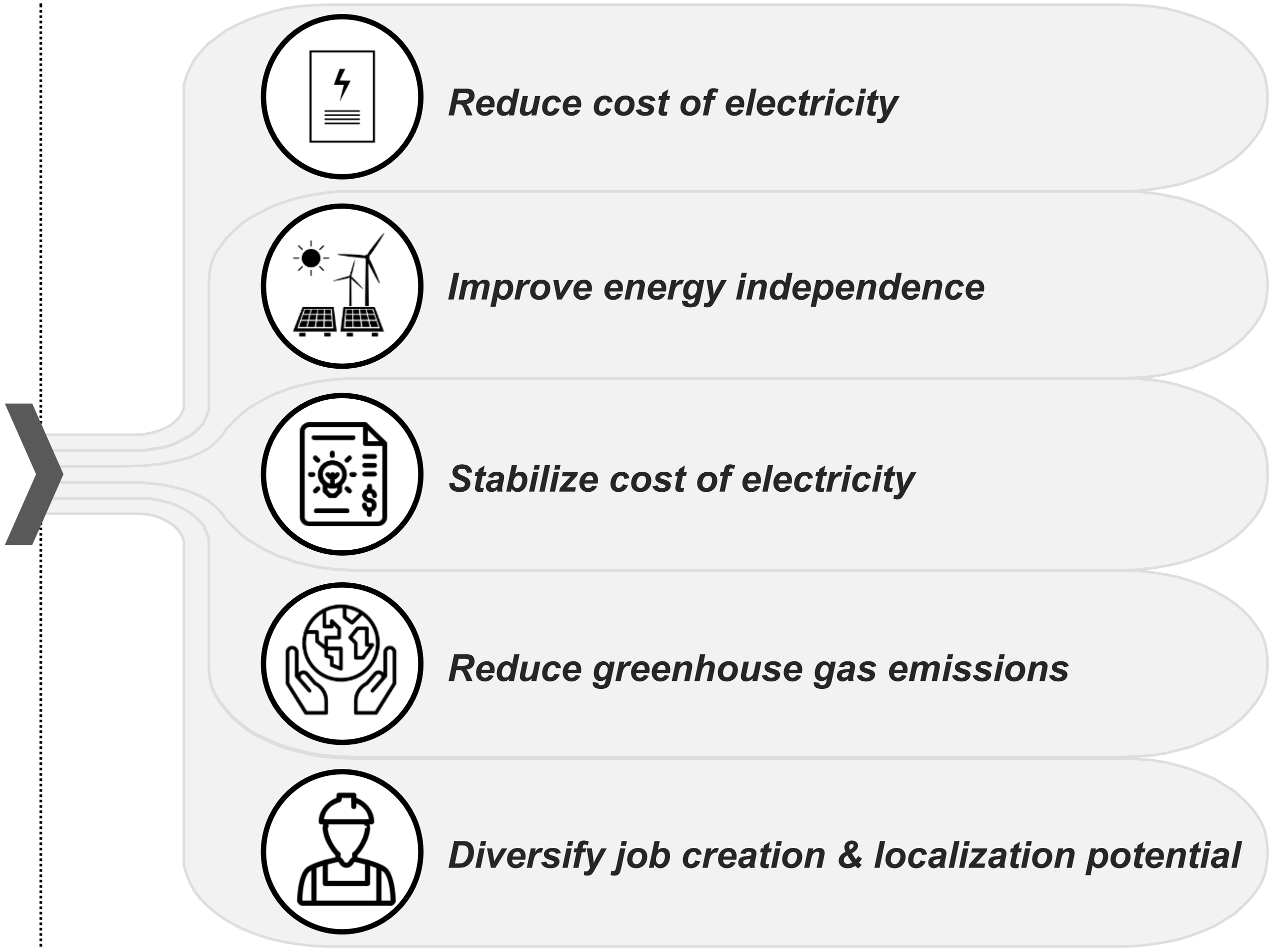
In comparison with other regional countries, Lebanon's aspirations for solar and wind energy tend to be conservative

Generation Mix Share of Solar and Wind

Mediterranean and GCC Area, % of TWh



Advantages of Renewable Energy

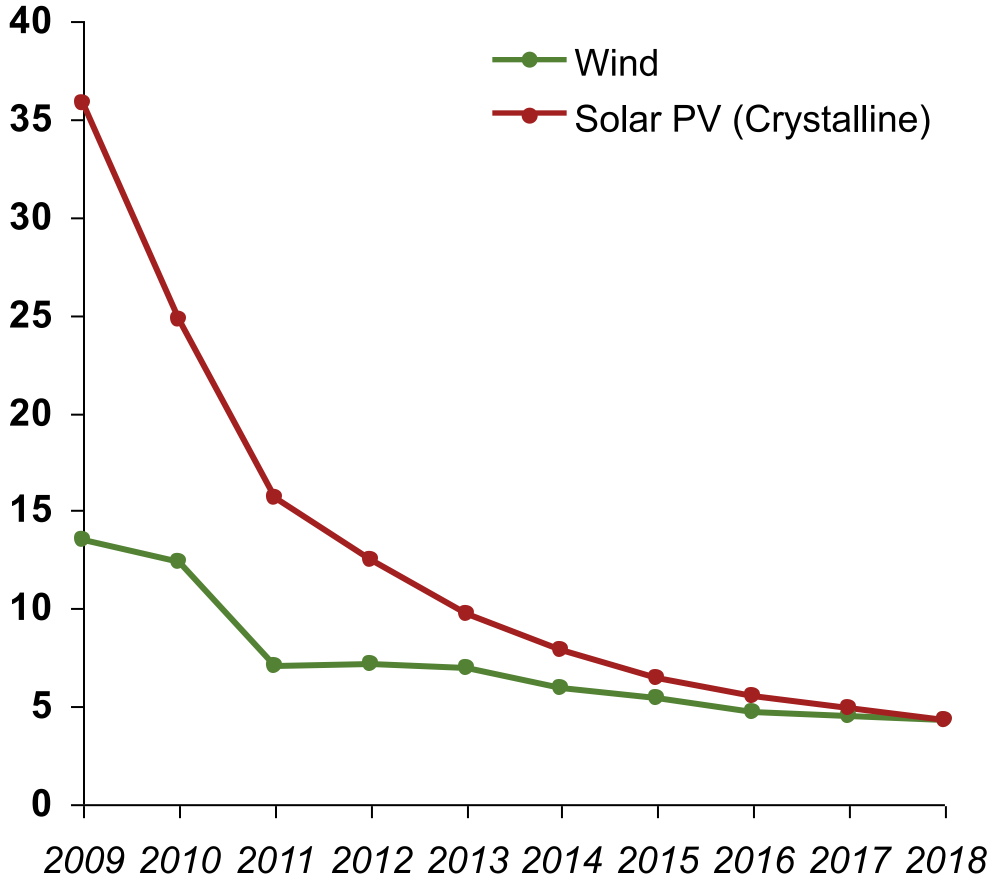


1) Iberia includes Portugal, Spain, British Crown colony of Gibraltar and Andorra

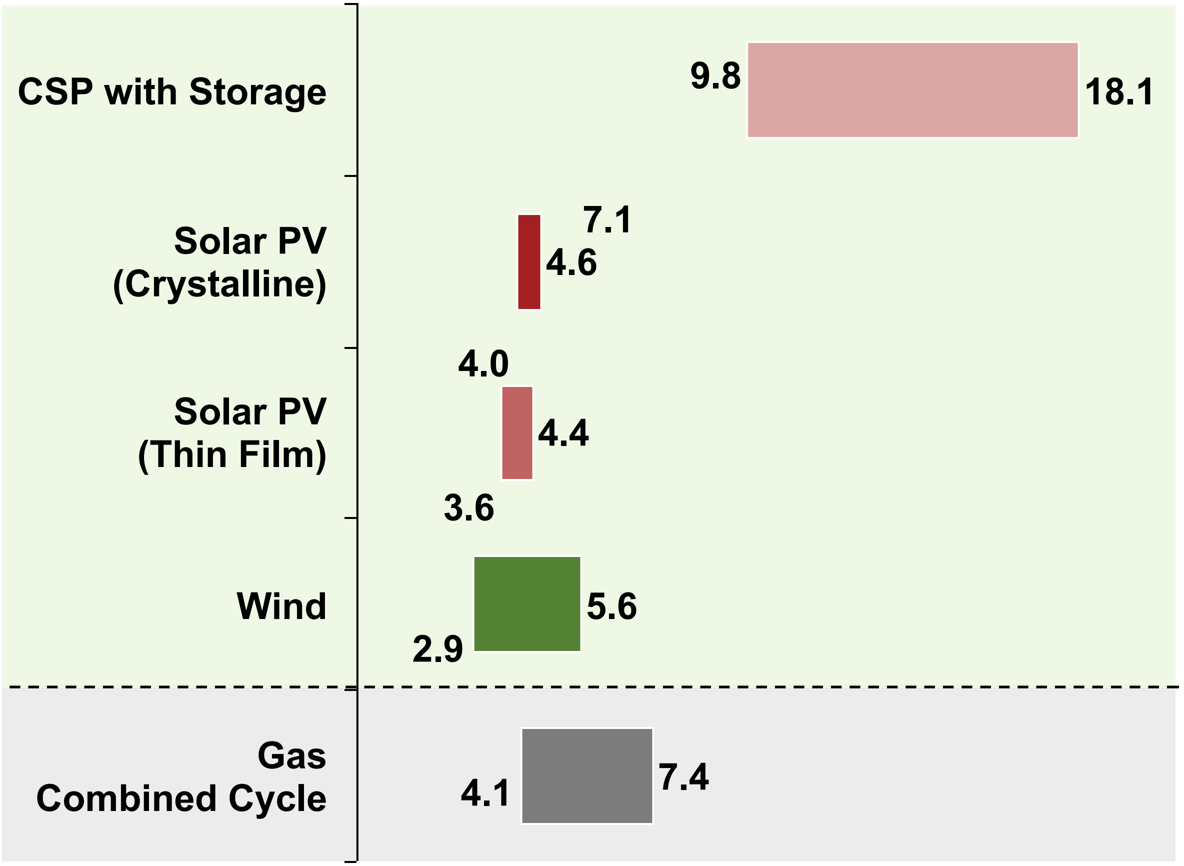
Source: Team Analysis

Solar PV and Wind LCOEs have fallen below those of conventional power generation

Wind and Solar PV LCOE Evolution
US c/kWh

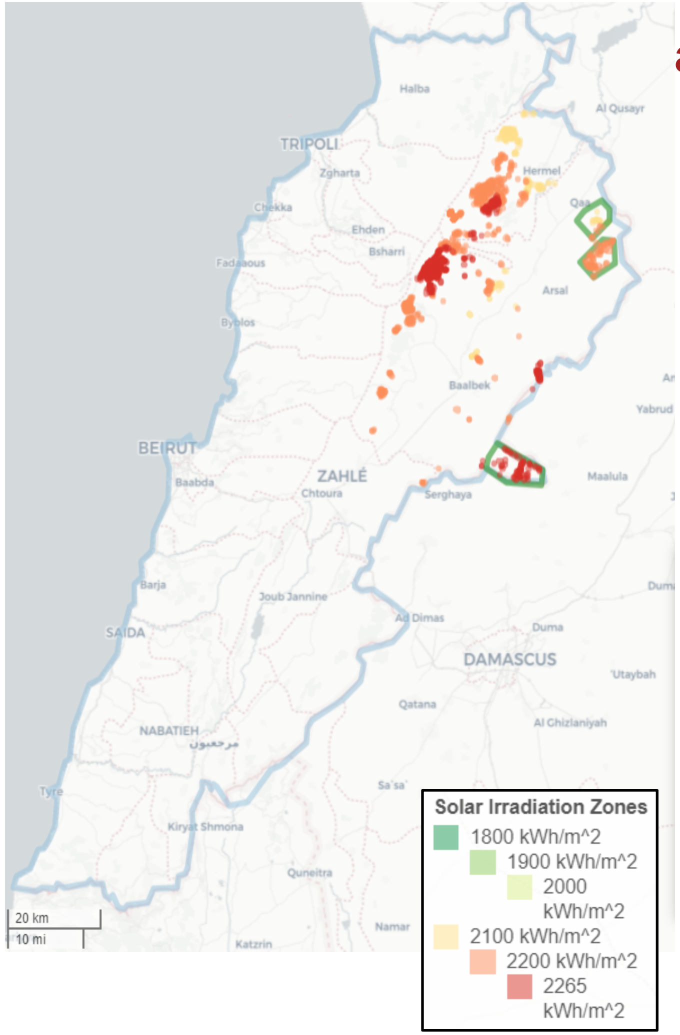


Unsubsidized LCOE Comparison
2018 US c/kWh



Source: Lazard; Strategy& Analysis

A recent review of land availability for solar energy projects by the CNRS-L across Baalbak - Hermel reveals a potential of 7 GW



anon

PRELIMINARY

Administrative Zone	Area (km²)	Potential Capacity[1] (GW)
Hermel Djebab	37	2.3
Nabha / Ainata / Barka	30	1.9
Tfail / Ain El-Jaouzeh	13	0.8
Ras Baalbek / Arsale	10	0.6
Charbine El Hermel	8	0.5
Dair El-Ahmar	7	0.4
Hermel Zighrine	4	0.2
Al-Qa Bayoun	2	0.1
Total	**111**	**7.0**

Surveyed and selected land plots exclude:

Private-Owned Lands
Plots readily available to the government for renewable projects

Hazardous Lands
Exposed to landslides, earthquakes, fires and floods, etc.

Reserved Lands
For agricultural use, forestry, historical sites, wetland & water bodies, etc.

Lands Not Suitable For Solar
Smaller than 0.5 km², non-south facing slopes, slopes of more than 30º, etc.

1) Does not account for storage potential
Note 1: Analysis does not account for impact of altitude
Note 2: The land assessment exercise was conducted by the CNRS-L and not verified by Strategy& and the Issam Fares Institute
Source: Center for Remote Sensing within the National Council for Scientific Research, Team Analysis

Key questions for Lebanon

01 What is the real potential of renewable energy in Lebanon's power sector energy mix?

02 What pre-requisites enable the successful development of Lebanon's renewable energy sector?

03 What is the implementation roadmap that would ensure streamlined delivery on the renewables agenda?

2 Lebanon's real potential for renewable energy

Three energy mix scenarios were defined to determine the optimal renewables penetration

Lebanon 2030 Energy Mix Scenarios

	CIP Plan[2]	Green Transition	Leapfrog Renewables
Land availability[1] for RE	**Land use based on CIP plan:** 7 Km² Solar 100 Km² Wind 3 Km² CSP	**Public lands limited to:** 45 Km² Solar 100 Km² Wind 5 Km² CSP	**Public land limited :** 111 Km² Solar 100 Km² Wind 5 Km² CSP
Grid upgrades	**Upgrade based on CIP Plan:** • Substations to 66 kV (regional) and 220 kV (main cities) • 25 added interconnections between cities • 400 kV interconnections with neighboring countries[3]	**Grid upgrade enabling yearly additions of:** 1,000 MW Solar 50 MW Wind 500 MW CSP 1,000 MW NG	**Smart grid upgrade enabling yearly additions of:** 2,000 MW Solar 100 MW Wind 500 MW CSP 2,000 MW NG
Barges Availability	**Increased to 825 MW by 2020 and retired in 2022**	**Maintained at 385 MW and retired in 2022**	**Maintained at 385 MW and retired in 2022**

1) Land requirements are assumed to be 60 MW / Km² for solar PV, 4.5 MW / Km² for wind and 30 MW / Km² for CSP; 2) CIP Plan assumes capital projects are finalized as per the plan's approved dates;
3) Includes Syria, Jordan, Egypt, Turkey
Note: All analysis developed based on LNG gas prices of 10 $/mmBTU;
Source: Team Analysis

Each scenario was assessed along five strategic priorities for the country to determine the optimal renewables penetration

Energy Mix Strategic Priorities

ILLUSTRATIVE

System cost

Overall generation and transmission costs

Environmental impact

Greenhouse gas emissions

System reliability

Uninterrupted supply of electricity the earliest possible

Socio-economic impact

Job creation and GDP value add

Energy security

Reduction of liquid fuel and gas imports

Source: Team Analysis

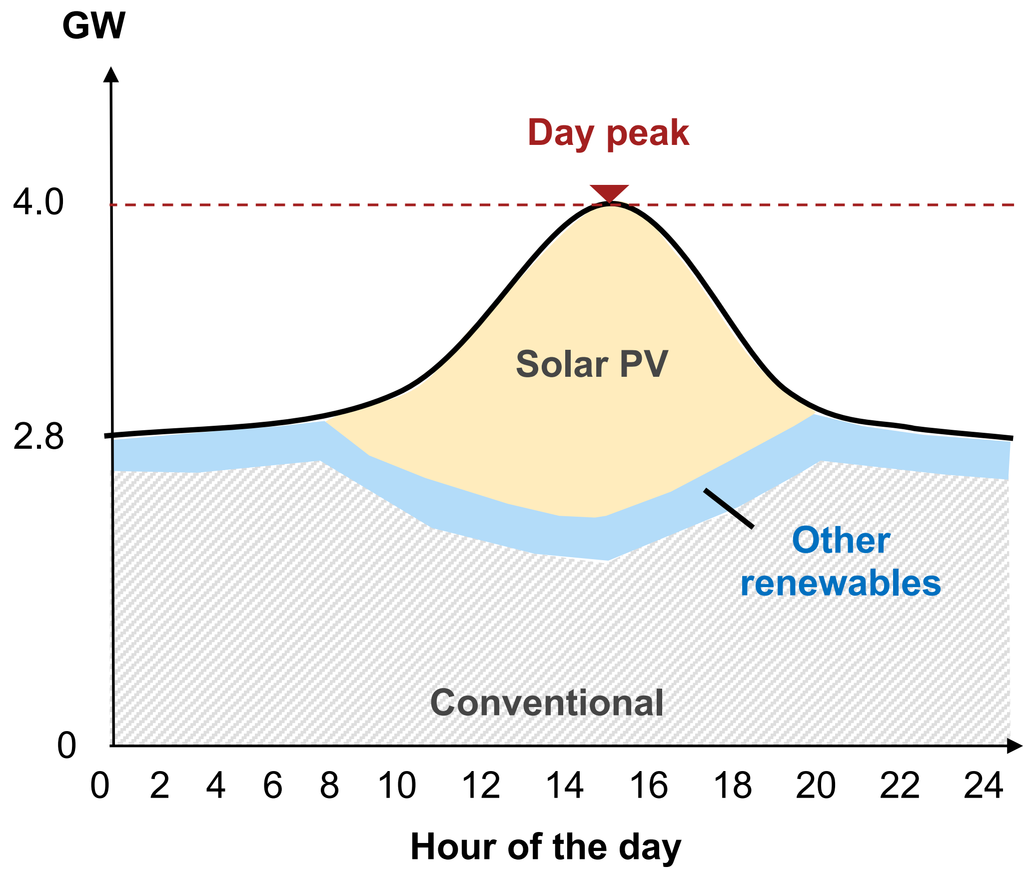
As a starting point, the scenarios were optimized to generate the least generation cost using a power dispatch model

Scenarios Modeling Methodology

Dispatch model

- Least cost optimization over entire analyzed period (2020-2030)
- Hourly supply-demand profiles and solar resource availability ensuring output accuracy
- Capacity retirement plan in-line with asset technical lifetime
- Asset construction lead time accounted for capacity ramp-up

ILLUSTRATIVE

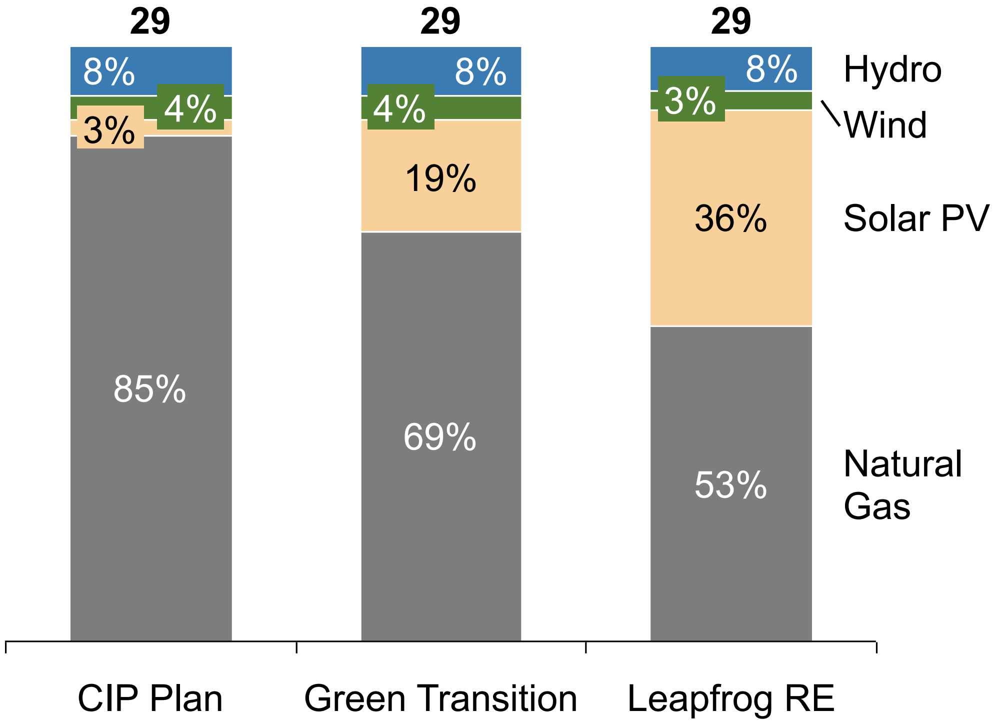


Source: Team Analysis

"Green Transition" increases the share of solar and wind in the generation mix from 7% to ~30%, leading to significant benefits

2030 Generation Mix

TWh



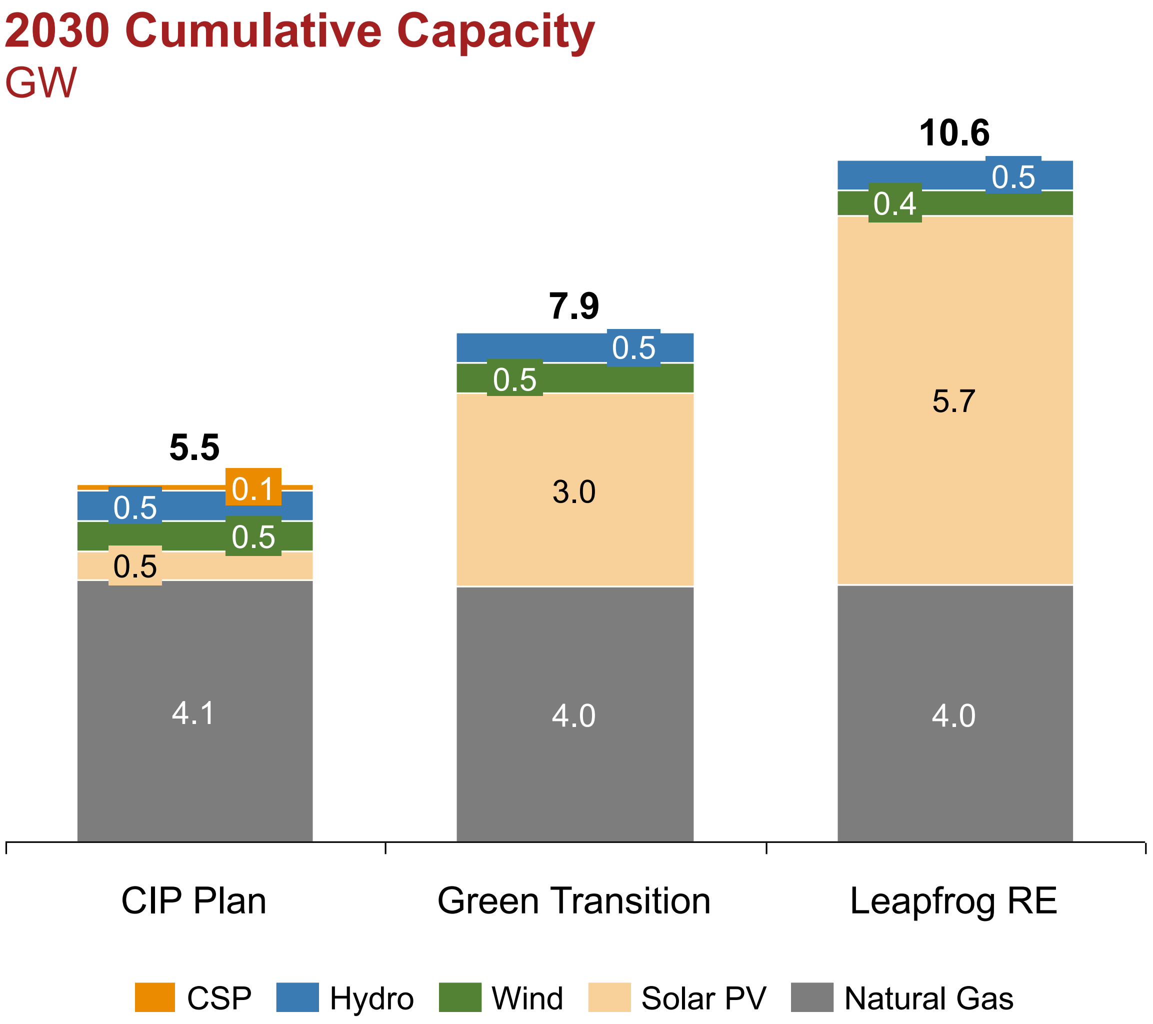
	CIP Plan	Green Transition	Leapfrog RE
2030 Capacity (GW)	***5.5***	***7.9***	***10.6***

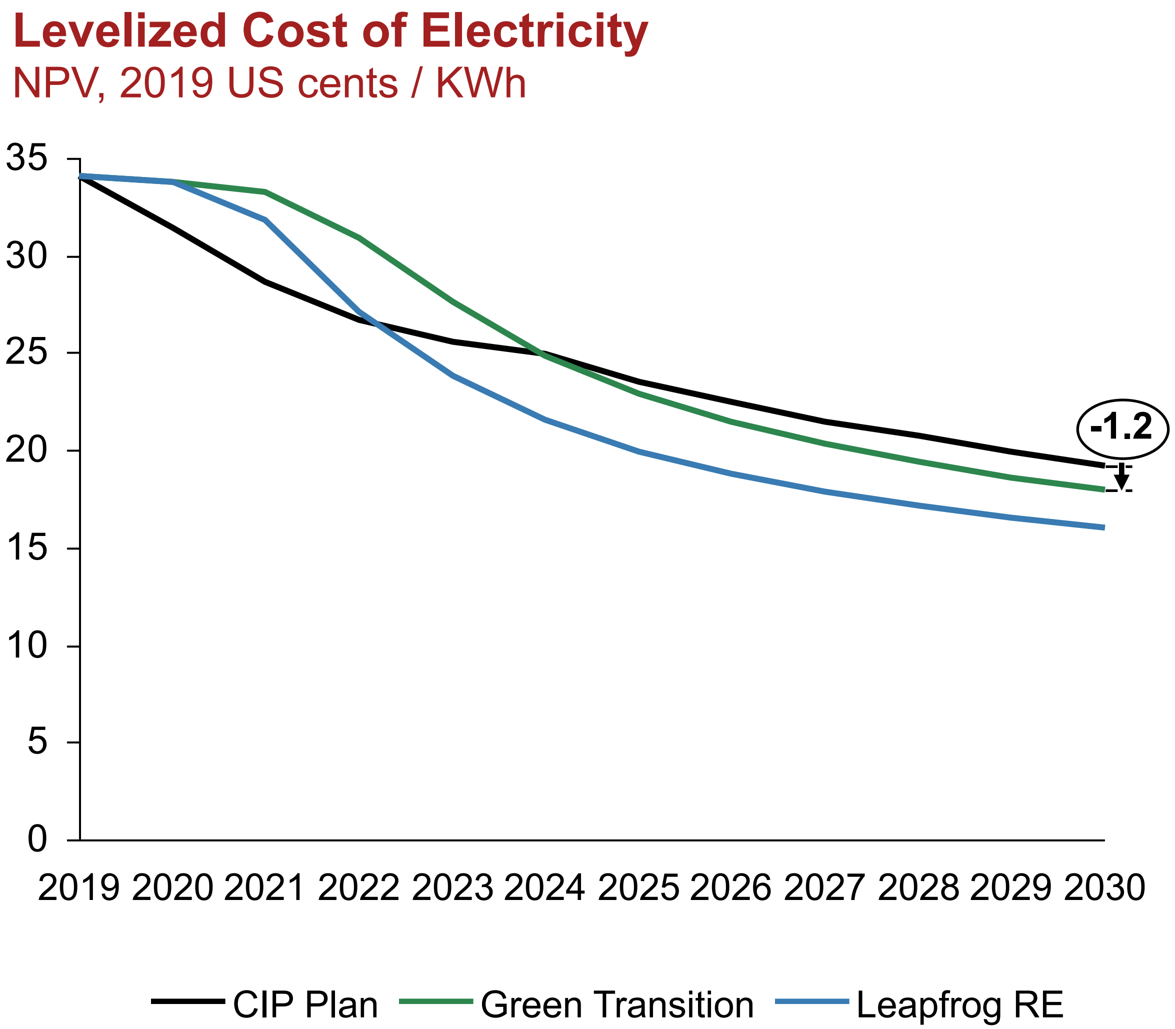
	CIP Plan	Green Transition	Leapfrog RE
'19-'30 NPV of LCOEs[1] (cents / KWh)	19.2	18.0	16.0
Net savings[2] (Bn USD)		+ 2.1	+ 5.8
Liquid fuels displacement (Year)	2029	2025	2023
EDL fuel savings[3] (Bn USD)		+2.1	+3.2
GHG reduction[4] (%)		- 16%	- 30%
Job creation (FTEs)	~1,200	~1,900	~2,700
Local value add[5] (%)		+ 7%	+ 17%

1) LCOE expected to reach 35.8 cents/KWh under a "Do Nothing" scenario; 2) Net savings compared to "Do Nothing" in Bn USD: CIP Plan (30.3); Green Transition (32.4); Leapfrog RE (36.1); 3) Fuel savings compared to "Do Nothing" in Bn USD: CIP Plan (-1.1); Green Transition (1.0); Leapfrog RE (2.1); 4) GHG Reduction compared to "Do Nothing": CIP Plan (-44%); Green Transition (-53%); Leapfrog RE (-61%); 5) Localized spending assumed to be 100% for EPC, 5-10% for machinery and equipment, and 100% for operational non-fuel O&M

Source: Team Analysis

“Green Transition” installs 3.5 GW of solar and wind by 2030 and reduces the LCOE by 1.2 c/kWh compared to CIP Plan

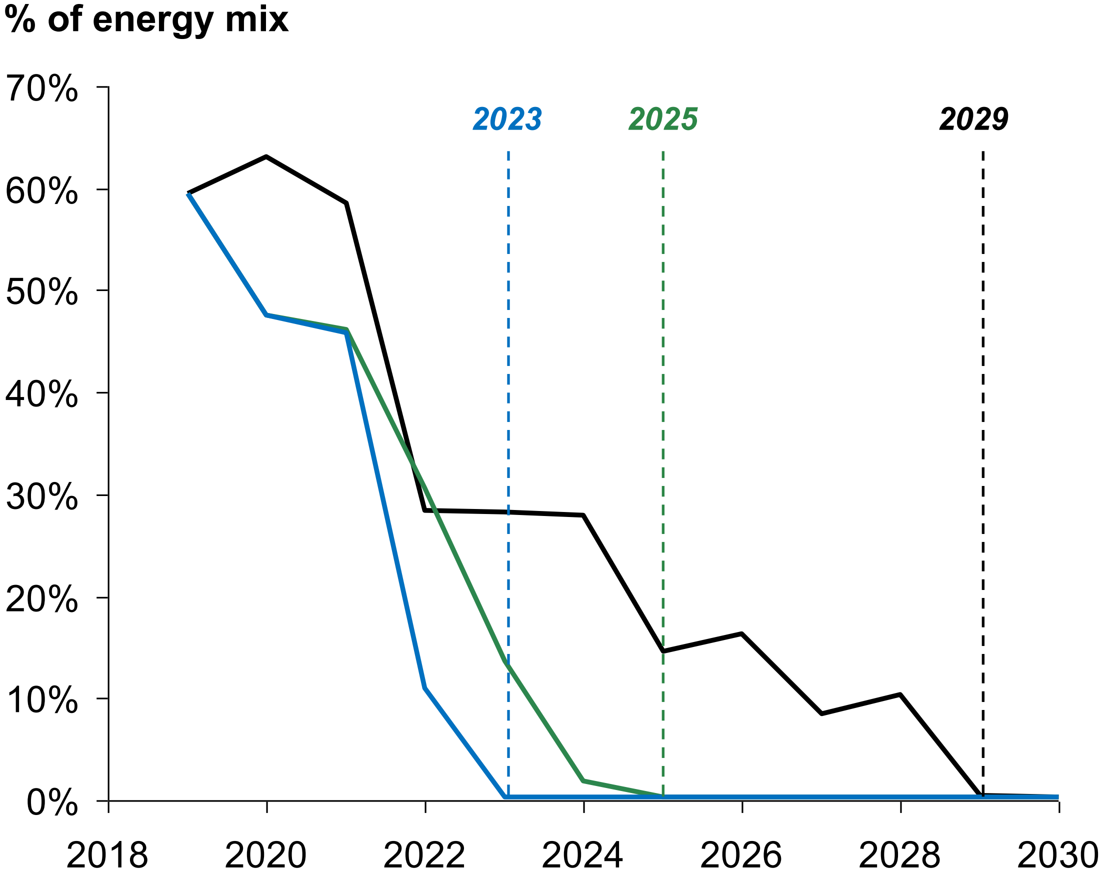




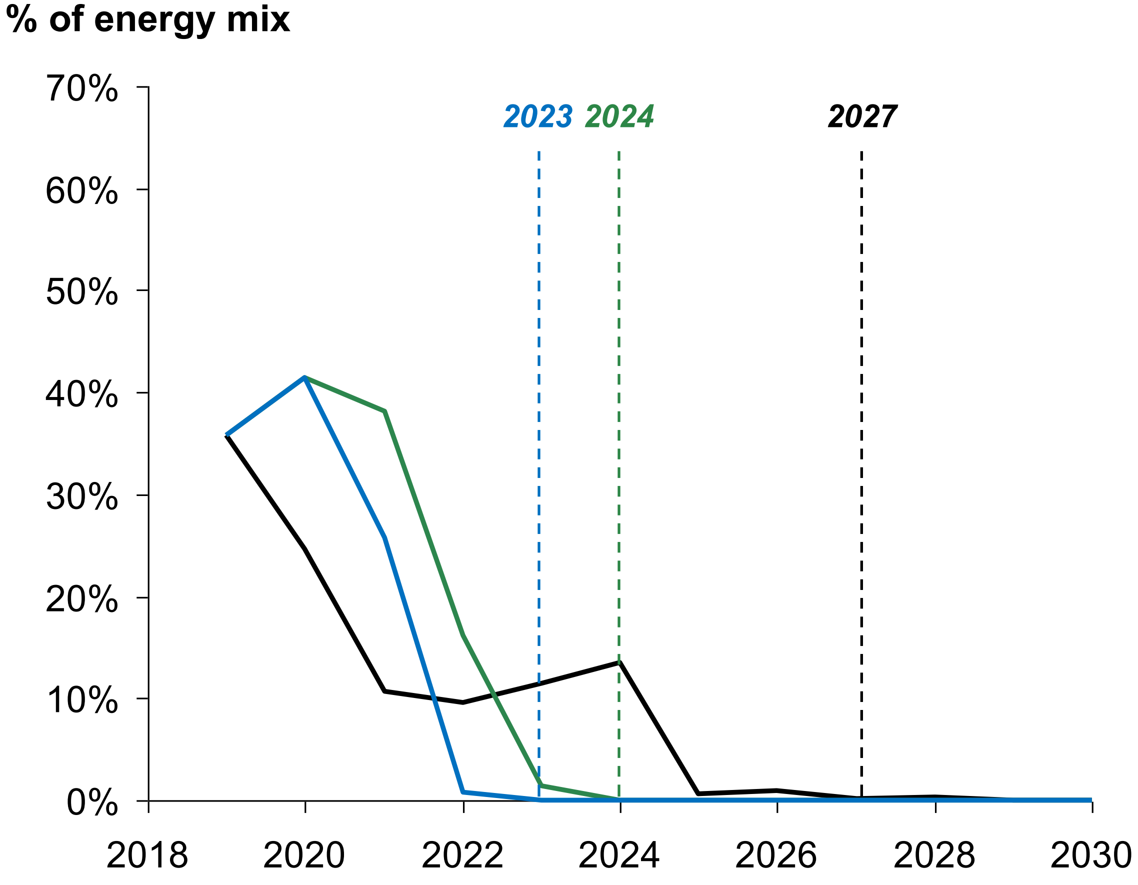
Source: Team Analysis

“Green Transition” expedites the phase-out of all liquid fuels to 2025 instead of 2029 under “CIP Plan”

Liquid Fuels[1] Displacement



Private Diesel Displacement

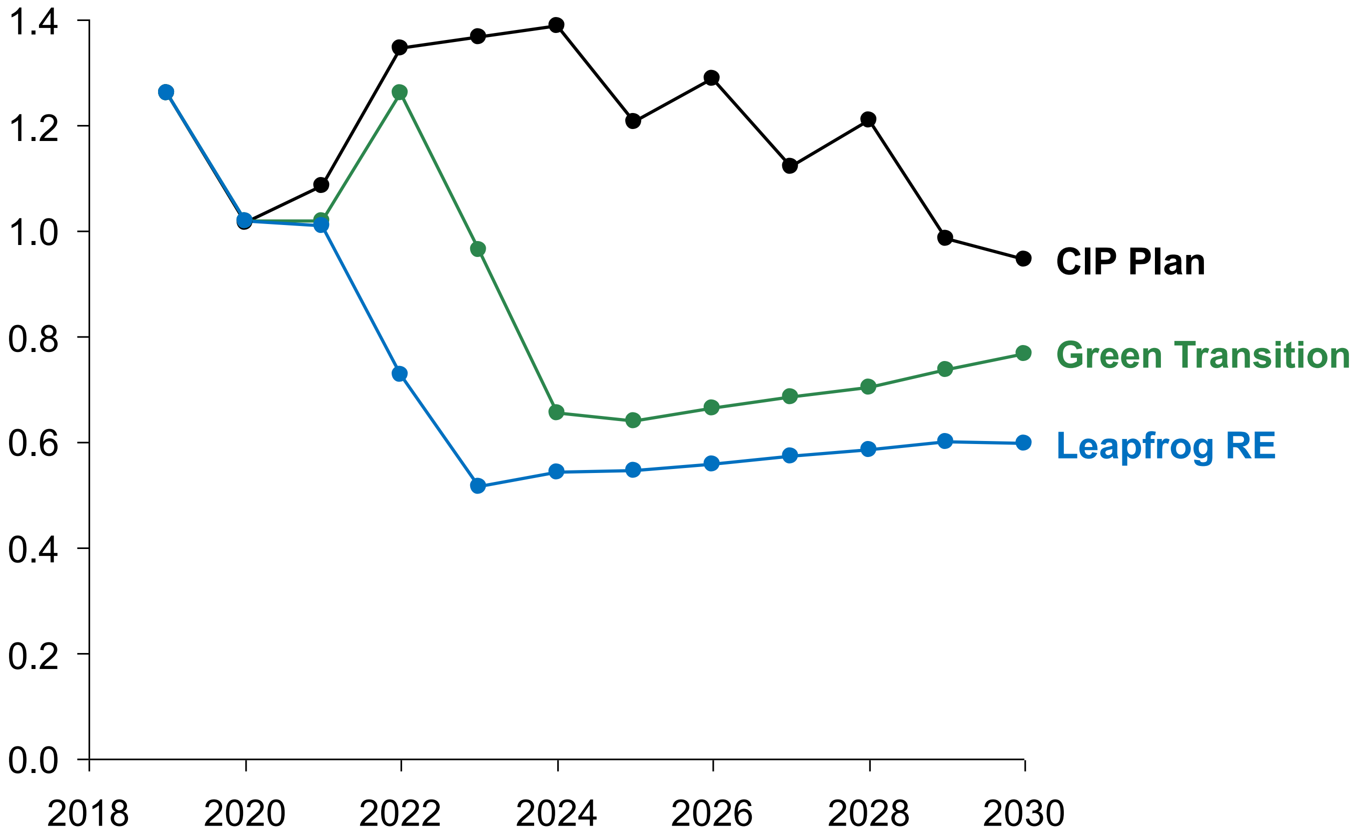


CIP Plan — Green Transition — Leapfrog RE - - - Complete displacement

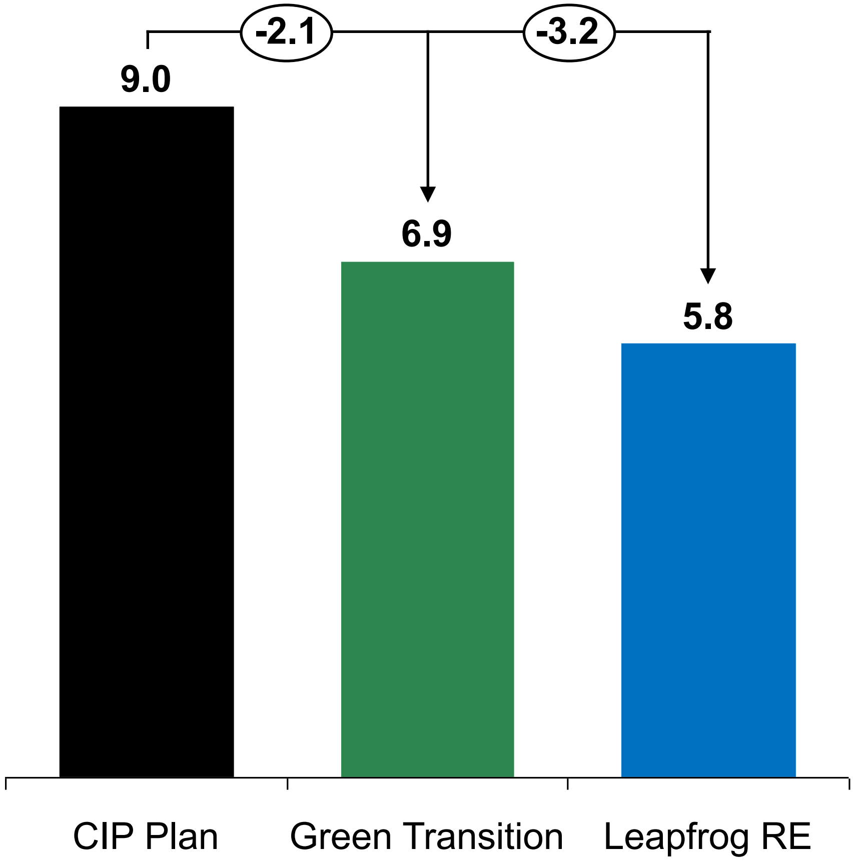
1) Includes RFO, Barges and Diesel
Source: Team Analysis

This translates into savings of ~USD 2.1 Bn in fuel cost between 2019 and 2030

Annual Fuel Cost[1]
Bn USD



Cumulative Fuel Cost[1]
2019 – 2030, Bn USD

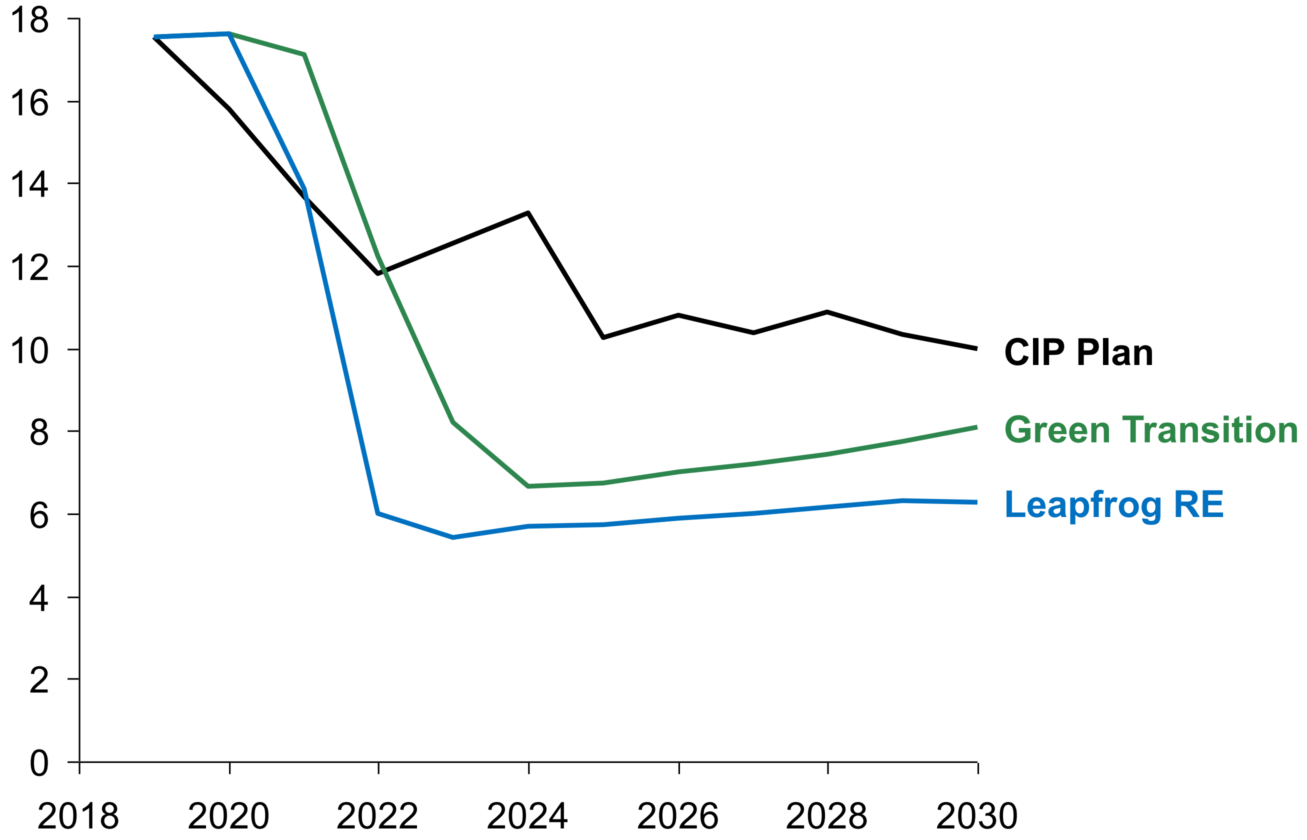


1) Calculated at fixed prices for each type of fuel in USD / mmBtu: NG (11), RFO (32), Diesel (42)
Source: Team Analysis

In addition, “Green Transition” reduces greenhouse gas emissions by ~15% compared to the “CIP plan”

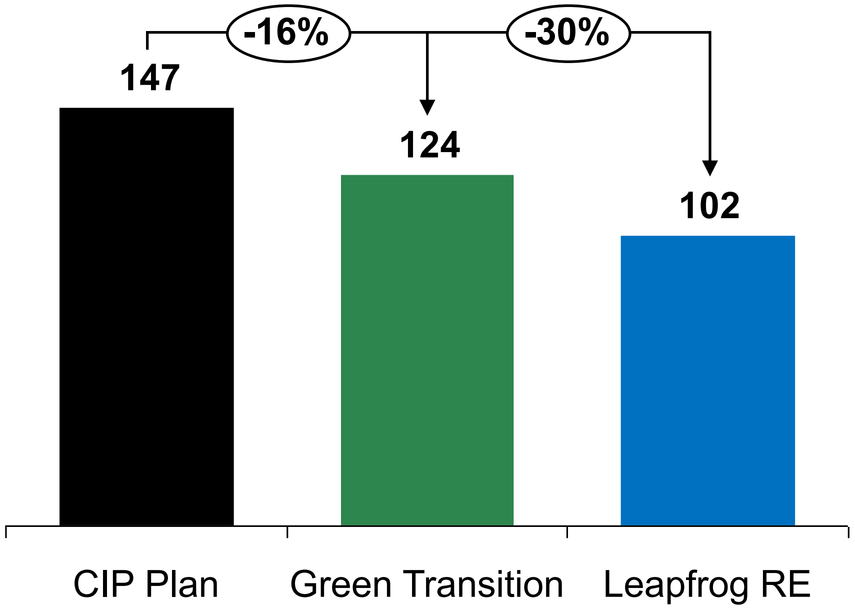
Yearly Greenhouse Gas Emissions[1]

Mn Tons of CO_2 Equivalent



Total Greenhouse Gas Emissions

Mn Tons of CO_2 Equivalent, (2019 – 2030)



Avoided Healthcare Costs

NPV USD Bn, (2019 – 2030)

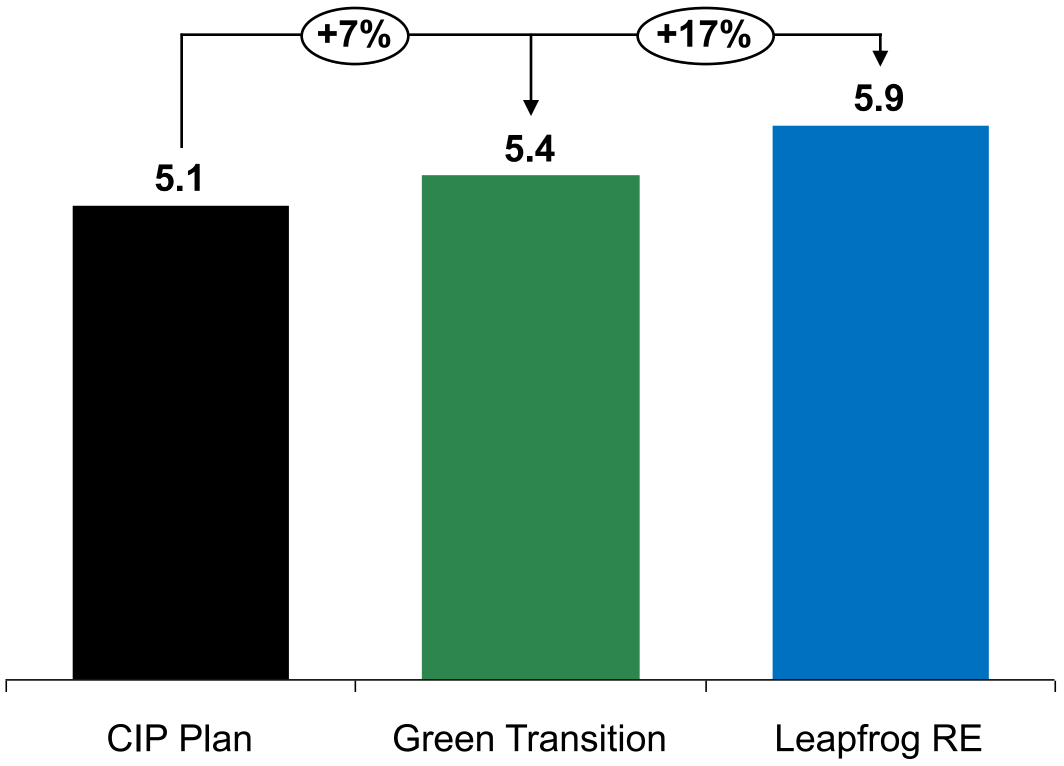
CIP Plan	Green Transition	Leapfrog RE
4.6	5.4	6.4

1) Greenhouse gas emissions include water vapor, carbon dioxide (CO2), methane (CH4), sulfur oxide (SOx), Nitrogen oxide (NOx) and others; Operational emissions of renewable energy are considered negligible while for conventional energy the values in Kg of CO2 / MWh are: Natural Gas (399); Residual Fuel Oil (700); Diesel fuel (700); Diesel Distributed Generators (1143)

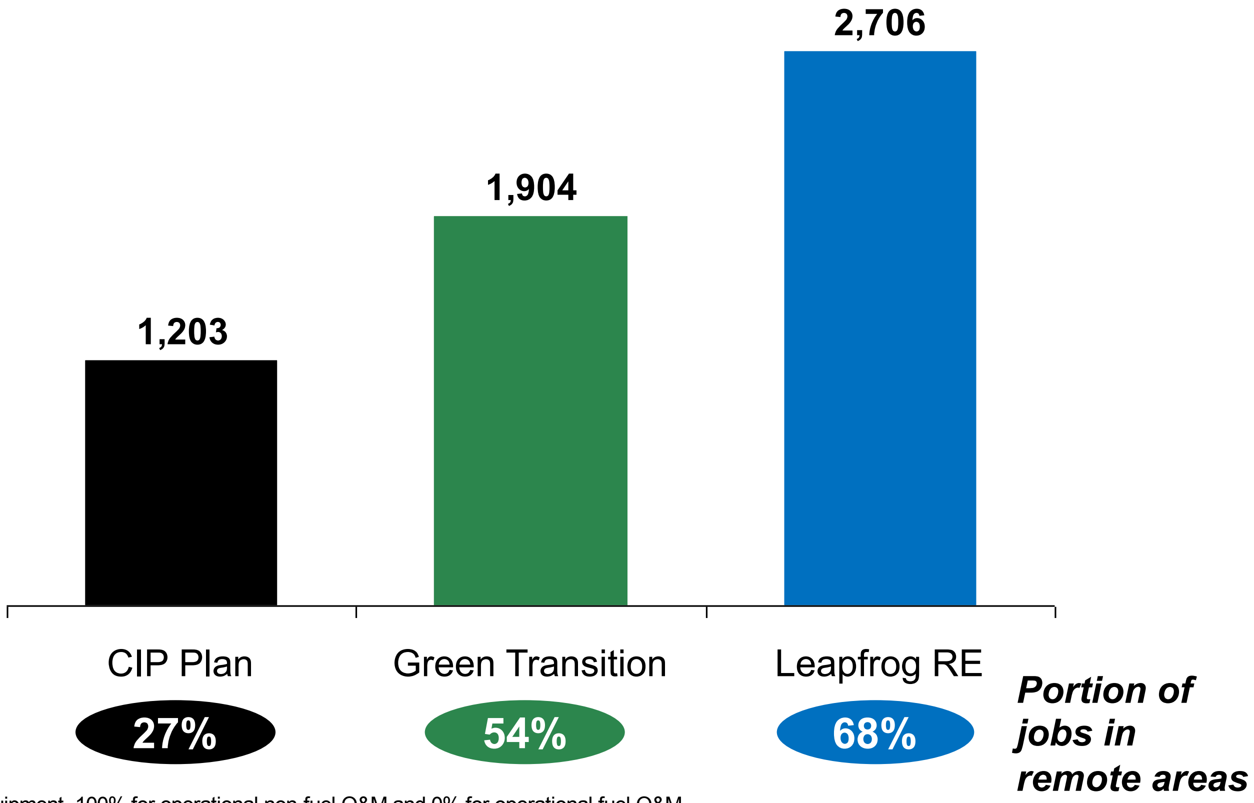
Source: Team Analysis

"Green Transition" offers a higher impact on GDP and number of sustainable jobs when compared to CIP

Local Value Add[1]
2019 Bn USD

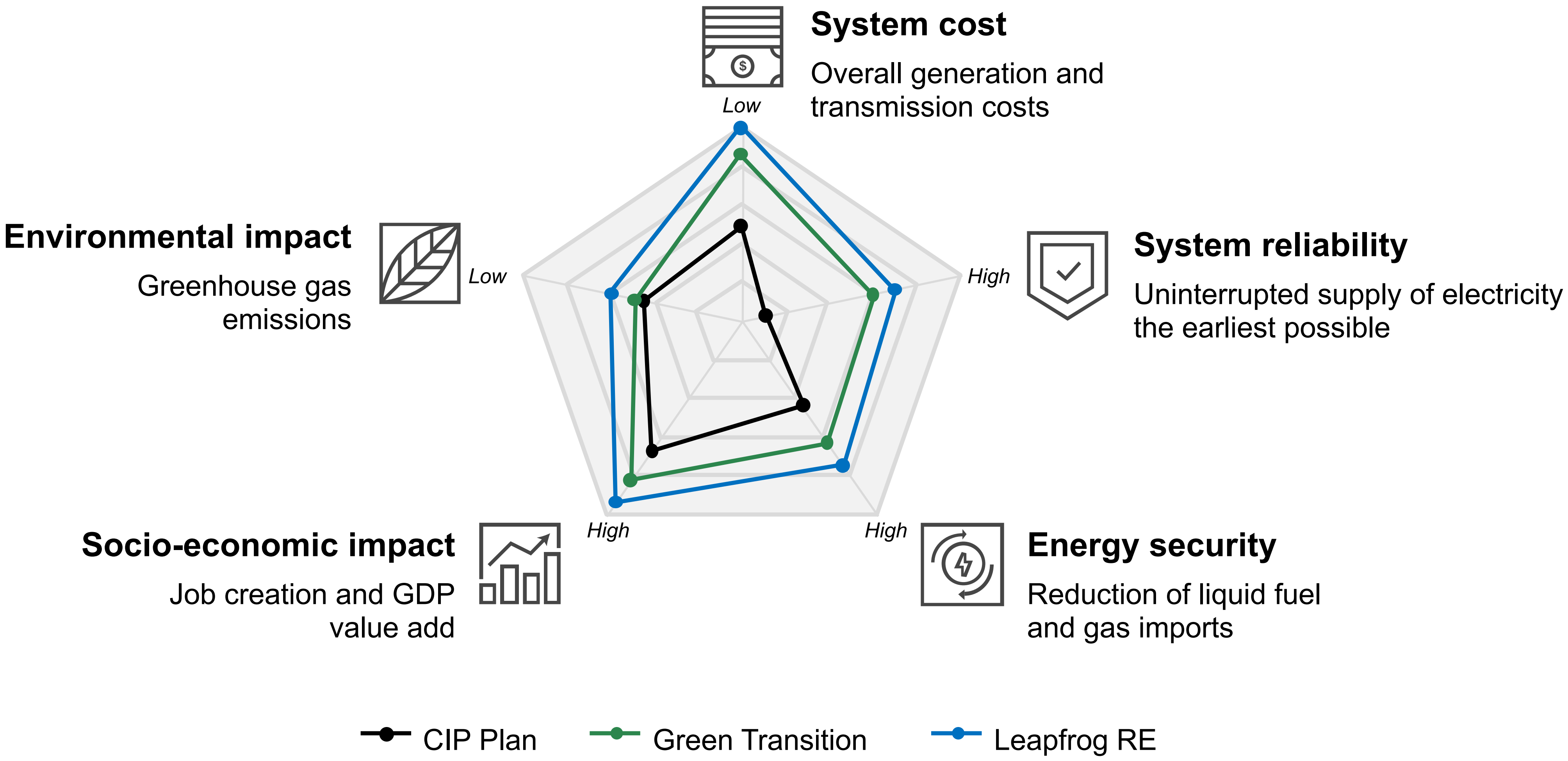


Sustainable Job Creation[2] in 2030
FTEs



1) Localized spending is assumed to be 100% for EPC, 5-10% for machinery and equipment, 100% for operational non-fuel O&M and 0% for operational fuel O&M
2) Operations and Maintenance jobs created in FTE/MW: Wind (0.3); Hydro (0.3); PV (0.3); CSP (0.5); Barges (0.0); Conventional (0.14); Diesel Generators (6.33)
Source: Team Analysis

In summary, "Green Transition" scores significantly higher than CIP across all of Lebanon's five strategic priorities …



Source: Team Analysis

… Yet, the Government should consider the "Leapfrog" Scenario in case two pre-requisites are secured

Prerequisites for "Leapfrog" Scenario

Land Availability

- Confirm availability of suitable land to install up to 5.7 GW (90 Km^2) of solar PV capacity. Suitable land is defined as:
  - Readily available to the government
  - Not exposed to landslides, earthquakes, fires and floods, etc.
  - Not reserved for agricultural use, forestry, historical sites, wetland & water bodies, etc.
  - Larger than 0.5 km^2, non-south facing, and slopes less that 30^0

Significant Grid Upgrades

- Ensure plans are in place and sufficient funds are made available to significantly upgrade the electrical grid and enable:
  - Integration of large number of utility scale renewable energy projects across the grid
  - Adoption of smart grid technology

Source: Team Analysis

To achieve "GT" benefits, ~8 GW of capacity must be installed by 2030 at an incremental yearly capital cost of ~$175 Mn

Scenarios Net Savings and Required Enablers Summary

	CIP Plan	Green Transition	Leapfrog Renewables
Installed Capacity by 2030 *(GW)*	*0.47 Hydro 0.45 Solar 0.45 Wind 0.10 CSP 4.05 Gas* **~5.5 GW**	*0.47 Hydro 3.00 Solar 0.45 Wind 4.00 Gas* **~8.0 GW**	*0.47 Hydro 5.70 Solar 0.40 Wind 4.00 Gas* **~10.5 GW**
Average Annual CapEx[1,2] *(Mn USD)*	**341**	**+176**	**+336**
Annual Operational Savings[1] *(Mn USD)*		**-335**	**-778**
Land Area Required	*7 km² Solar 100 km² Wind 3 km² CSP*	*45 km² Solar 100 km² Wind*	*86 km² Solar 88 km² Wind*
Grid Upgrades Needed	*Basic*	*Moderate*	*Significant with Smart Grid Integration*

1) Payments are NPV'ed at a discount factor of 10%
2) CapEx payments account for the period between 2020 and 2030 and for grip upgrade costs of Bn 0.6 USD for CIP, Bn 0.9 USD (Green Transition), and Bn 1.2 USD (Leapfrog Renewables)
Source: Team Analysis

3 Pre-requisites for successful renewables sector development

The private sector can play a key role in the rapid deployment of renewable energy capacity in Lebanon

Private Sector Contribution to Energy Sector

Private sector contribution benefits

01 **Reduce government financing requirements** by shifting capital injection to the private sector

02 **Improve efficiency** in capital, & operations avoidance of state dominance and situations of conflict of interest

03 **Increase the competitiveness of the power sector structure** through competitive bidding for projects

04 **Increase foreign direct investments** and help reduce the deficit in Lebanon's trade balance

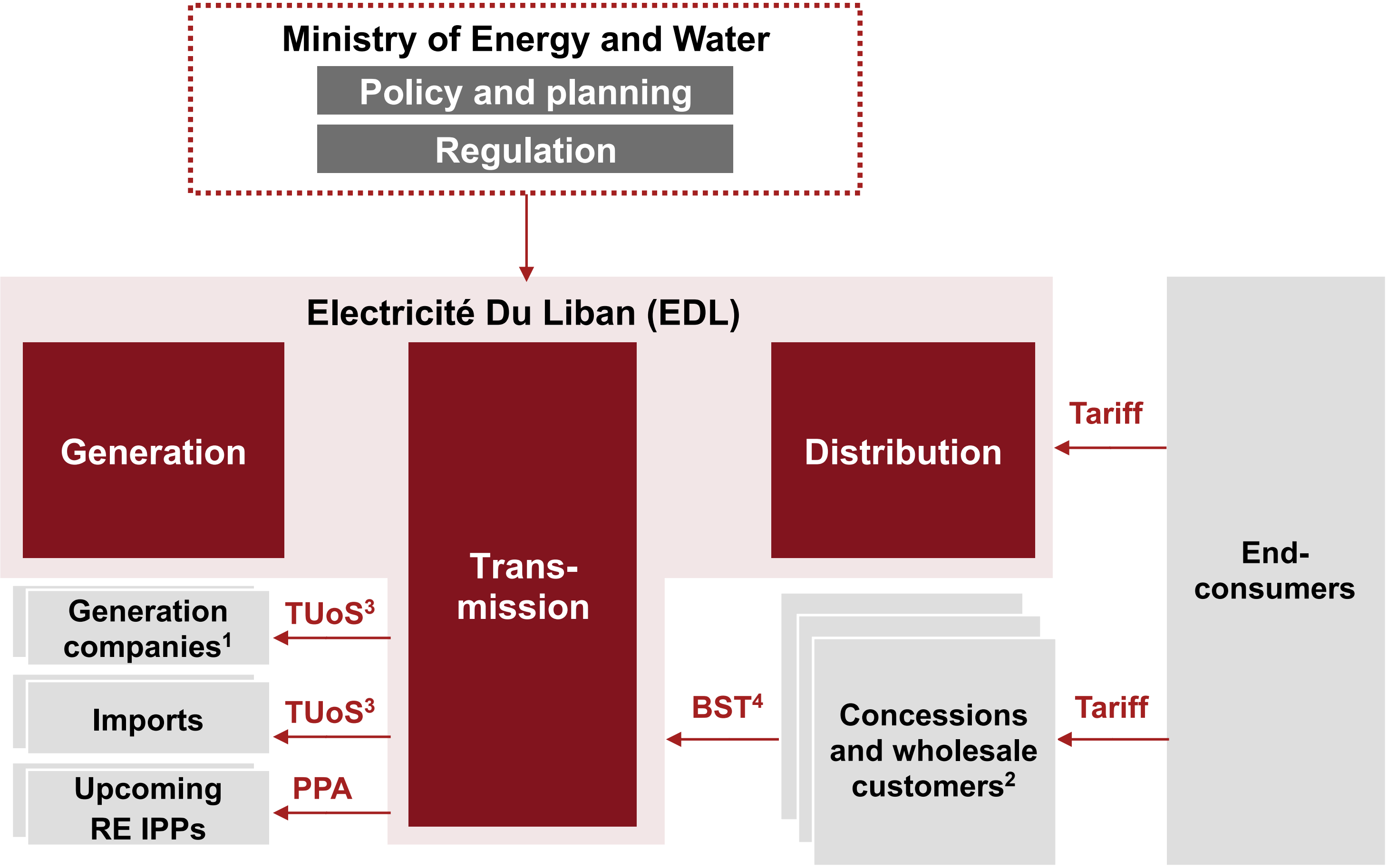
Benchmark countries	Conventional	Renewables
KSA	Public Sector Owned	Private Sector Owned
Morocco	Public Sector Owned	Private Sector Owned
Abu Dhabi	Public Sector Owned, Private Sector Owned	Private Sector Owned
Egypt	Private Sector Owned	Private Sector Owned
Turkey	Private Sector Owned	Private Sector Owned
Spain	Private Sector Owned	Private Sector Owned
France	Public Sector Owned, Private Sector Owned	Private Sector Owned

Private Sector Owned | Public Sector Owned

Source: Team Analysis

However, the current power sector structure in Lebanon does not encourage private sector participation in RE projects

Current Electricity Sector Structure in Lebanon



Overview

- EDL is the sole electricity off-taker and LCEC[5] (within MEW) tenders renewable energy capacity
- EDL suffers from a budget deficit due to a non-cost-reflective tariff set since 1996
- EDL's financial status are inducing high financing costs for private RE investments (16% in Lebanon compared to 7% in Germany) due to:
  - Limited credibility of the electricity buyer
  - Weak market regulations
  - Limited grid system reliability

1) Litani, Kadisha, Bared, and Nahr Ibrahim, 2) Kadisha, Zahle (operating contract), Jbeil, Aley and Bhamdoun concessions
3) Transmission Use of System, 4) Bulk Supply Tariff, 5) Lebanese Center for Energy Conservation acting as the technical arm of the Lebanese Government
Source: UNDP, EDL, Team Analysis

Similar countries encouraged private sector participation by leveraging a set of structural and operational pre-requisites

Pre-requisites For Successful Private Sector Participation

		Morocco	Nigeria	Egypt	South Africa
Structural	Credible and financially robust off-take market	✓	✓	✗	✓
Operational	Clear and transparent project award mechanism	✓	✓	✓	✓
	Availability of pre-development studies[1] and land permits[2] to de-risk investment	~	~	~	~
	Partial or full grid upgraded to absorb renewables capacity	✓	~	~	✓

✓ *Full execution*
~ *Partial execution*
✗ *Not applied*

1) Pre-development activities include Preliminary Site Assessment, Site Master Plan, Environmental and Social Impact Assessment, Permitting and Authorization, Geotechnical Assessment, Hydrological Assessment, Preliminary Design and Energy Yield Assessment
2) Egypt, Morocco and Nigeria help bidders get access to lands or pre-allocate plots for renewable energy projects development
Source: Team Analysis

Countries attract private investments by setting up a RE off-taker, financially backed by MoF / global financial institutions

	Nigeria (2010 Onwards)	Morocco (2016 Onwards)
Generation	GenCos; IPPs	ONEE; IPPs
Tendering and off-take	NBET[1] *Guaranteed by World Bank*	ONEE; MASEN (Guaranteed by GoM)
T&D	DisCos	ONEE
Overview	• NBET established as an independent electricity buyer to drive private sector investment • NBET guaranteed by the World Bank in case it defaults on PPA payments • NBET acts as a credible, transparent, and creditworthy off-taker for IPPs	• Sector reform in 2016 expanded MASEN's mandate to include tendering and off-taking all renewable capacity • ONEE gradually transferred RE assets, contracts and employees to MASEN • ONEE will maintain tendering and off-taking thermal capacity

1) Nigeria Bulk Electricity Trading Company
Source: NBET Website, MASEN Website, Team Analysis

Countries are transitioning from FiTs to a competitive bidding scheme to increase transparency and reduce electricity cost

Egypt Project Award Scheme Evolution

Egypt

Timeline	*Early 1990's*	*2014*	*2017*
Award Scheme	**NREA (EPC)**	**Feed-in-Tariff**	**Competitive Bidding**
Project Capacity *(MW)*	**Any**	**Any** *(Until 2017)* **< 50 MW** *(Post 2017)*	**> 50 MW**
Tariff / LCOE *(USD/kWh)*	**Proposed by Egypt ERA[1]**	**Solar: 7.9 – 8.4** **Wind: 4.0 – 8.0**	**Solar: 2.7[2]** **Wind: Not Announced**
Contract *(# of years)*	**20**	**15**	**PPA for 20 years**
Mechanism Assessment	+ No new regulations required - No transparency in power cost - No incentive to minimize costs - Increased risk of corruption	+ Limited risk on private sector + Expedited renewable penetration - Difficult to set fair FiT value - Increased risk of corruption	+ Transparent process + Level playing field for all players + Lowest electricity cost - Time consuming process

1) Electricity Regulatory Authority; 2) Corresponds to ACWA Power's bid for the Kom Ombo solar PV project
Source: Egypt ERA, IRENA, Team Analysis

Competitive bidding schemes should define pre-qualification measures, bid requirements and evaluation criteria

Best Practice Competitive Bidding Components

NON-EXHAUSTIVE

Key Pre-Qualification Measures

Past Experience
Developer built and operated similar projects with capacity over 30%-50% of tender capacity

Financial Health
Proof of financial health of developer, such as credit rating, financial capacity, etc.

Legal Compliance
Documentation identifying the developer and proving its compliance with local laws, etc.

Agreements and Partnerships (if any)
Third-party involvement such as RE equipment manufacture to verify its reputation

Key Bid Requirements

Technology / Capacity
Alignment with renewable energy technology (solar, wind, CSP, etc.) and plant capacity

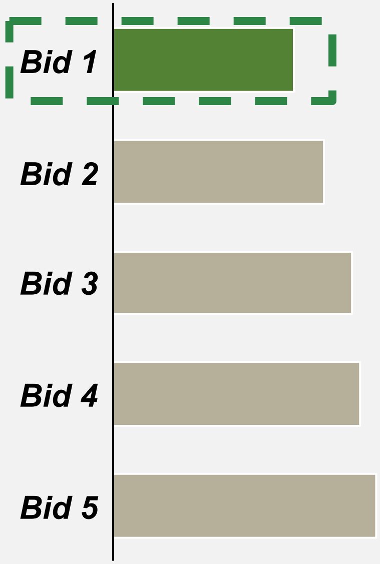
Financing
Proof of ability to secure funding through combination of equity and debt

Legal
Proof of enforceable consortium agreement, information accuracy and completeness, etc.

Socio-Economic Instruments
National employment percentage and local content needs (if needed)

Evaluation Criteria

LCOE



The qualifying bid with the **lowest LCOE** is awarded the project

1) Contingent on the tenderer's prescriptiveness of guidelines and requirements
Source: IRENA, Team Analysis

Operationally, pre-development studies help de-risk projects, level the field for all bidders and attract more global players

Pre-Development Studies Typical Package

1 Solar / Wind Resource Assessment

Data Measures of solar irradiance / wind speed and other parameters over a certain period of time

2 Geotechnical Assessment

Recommended optimal foundation design and soil improvement requirements, if any

3 Hydrological Assessment

Park's potential flood flows assessment and offsite peak flows for all regulated storm events

4 Environmental and Social Impact

Assessment of nearby environmentally sensitive areas, and ecologically sensitive species or residents

5 Preliminary Site Assessment

Preliminary topographical, geological, environmental and hydrological conditions and infrastructure interfaces

6 Park Master Plan

Site plan showing area with boundaries, fencing, access roads, internal roads, building locations, etc.

7 Park Preliminary Design

Preliminary design drawings and general specifications including tracks, roads, foundations, drainage, etc.

8 Energy Yield Assessment

Expected annual energy yield of the power plant based on park preliminary design

9 Stakeholders' Permits and Authorization

Necessary permits, authorizations and stakeholder non-objections such as land permits, etc.

Key Benefits

De-risk project *through accurate data measurements*

Level the field *for bidders by sharing common data*

Attract global investors *through easier access to data and permits*

Source: Team Analysis

Grid upgrades enable the integration of large scale renewables along with other benefits

South Africa Example

Grid Upgrade and Smart Grid Solution

Situation	• Aging electricity infrastructure • National agenda to increase RE penetration
Solution	• Upgrade of grid • Deployment of smart grid
High-Level Execution Roadmap	• Analysis of grid's status-quo • Identification of potential solutions • Simulation of representative grids • Evaluation of technologies • Network clustering

Smart Grid Benefits

- ***Increased integration of large-scale renewables***
- ***Faster restoration of electricity after disturbances***
- ***Reduced O&M costs for utilities and hence tariff on consumers***
- ***Reduced peak demand leading to lower electricity costs***
- ***More efficient transmission of electricity***
- ***Better integration electric vehicle charging stations***

Source: Team Analysis

In Lebanon, a RE tenderer/off-taker is the recommended sector structure to catalyze the development of the sector

	1 EDL EPC	2 EDL Tenderer & Off-Taker	3 RE Tenderer & Off-Taker
RE Generation	EDL	RE IPPs	RE IPPs
RE tendering and off-take	EDL	EDL	RE Off-taker
T&D	EDL	EDL	EDL
Options Assessment	? Easy to implement as no structure or regulatory reforms are required ⊖ Limited system transparency and accountability ⊖ Limited in-house capabilities in renewables project development ⊖ Large upfront capital requirements to develop renewable projects	? Easy to implement as no structure or regulatory reforms are required ⊖ Limited system transparency and accountability ⊖ Increased financing cost on developer leading to higher electricity cost	? Ability to secure financial guarantee from MoF or global financial institutions ? Reduced project financing cost due to support from global financial institutions ? Attractive structure for private sector participation ⊖ Structural and regulatory reforms required **Recommended Option**

Source: Team Analysis

Lebanon should also adopt a competitive bidding process and immediately initiate pre-development and grid upgrades

Lebanon's Operational Pre-requisites

Establish a clear and transparent competitive bidding process by defining the appropriate developers' pre-qualification requirements and tenders' evaluation criteria

Identify and **secure the plots of land** for project development and immediately **engage with technical advisors to initiate pre-development** activities

Review the grid upgrade plan and secure required funding to enable the penetration of utility scale renewables

Source: Team Analysis

4 Way forward

High-level Implementation Roadmap

01 Strategy approval / buy-in

- Socialize strategy to all relevant stakeholders to capture feedback and obtain buy-in
- Engage with Minister of Energy to present strategy to Council of Ministers for approval

02 Institutional and regulatory reform

- Update power sector policy (i.e., energy mix)
- Set up the Renewable Energy Off-taker
- Secure financial guarantee from MoF/global institutions

03 Pre-development and infrastructure readiness

- Identify sites for solar PV and wind projects
- Conduct sites pre-development activities[1]
- Review grid upgrade plan to enable utility RE penetration
- Secure funding for grid upgrade and initiate process

04 Tendering

- Develop project tendering pipeline
- Develop projects tendering process
- Initiate projects tendering and award contracts

1) Pre-development activities include Preliminary Site Assessment, Site Master Plan, Environmental and Social Impact Assessment, Permitting and Authorization, Geotechnical Assessment, Hydrological Assessment, Preliminary Design and Energy Yield Assessment
Source: Team Analysis

Appendix

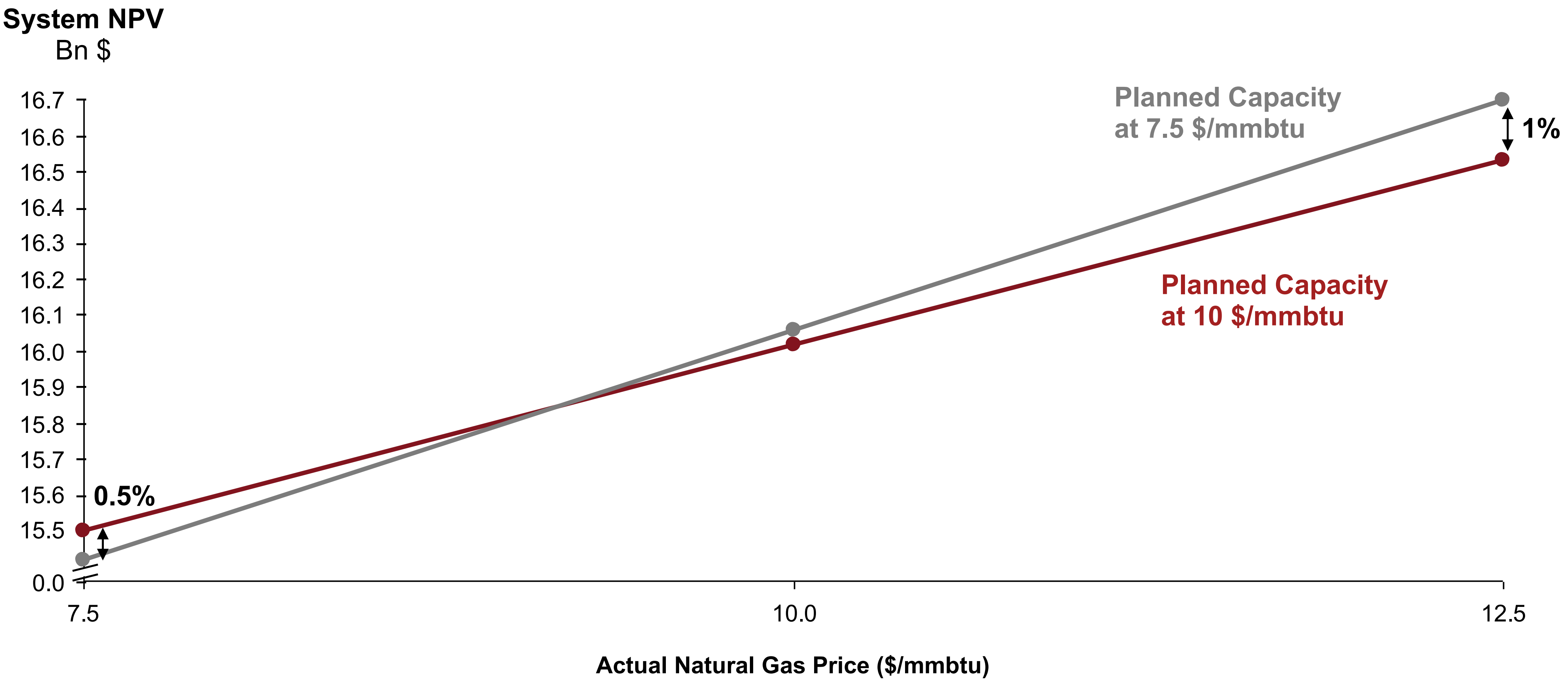
01 **Gas Price Sensitivity Analysis**

02 Results Compared to the “Do Nothing” Scenario

03 Capacity Profile and Capital Expenditures

04 Other Analyses

Gas price sensitivity analysis



Source: Team Analysis

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Four long term energy mix scenarios were defined to determine the optimal renewables penetration in Lebanon

Lebanon 2030 Energy Mix Scenarios

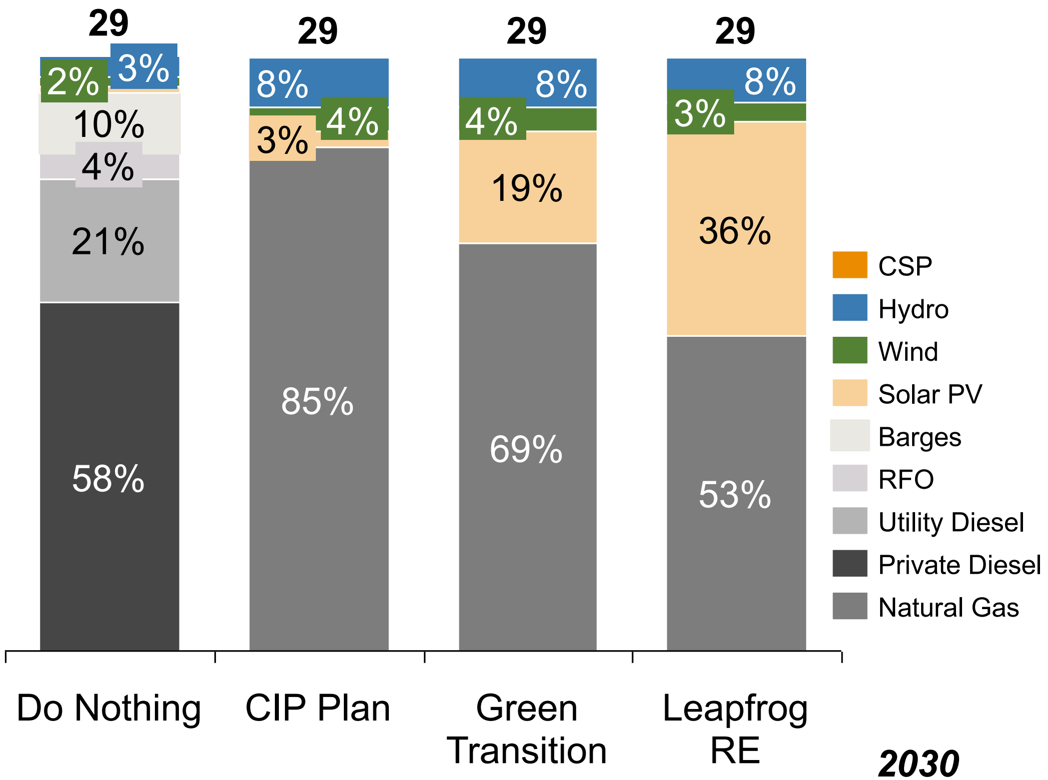
	Do Nothing	CIP Plan[2]	Green Transition	Leapfrog Renewables
Land availability[1] for RE	**Lands committed based on CIP plan:** 7 Km² Solar 155 Km² Wind	**Lands committed based on CIP plan:** 7 Km² Solar 155 Km² Wind 3 Km² CSP	**Government-owned lands limited to:** 45 Km² Solar 155 Km² Wind 5 Km² CSP	**Government-owned lands limited to:** 111 Km² Solar 155 Km² Wind 5 Km² CSP
Grid upgrades	**No Upgrade**	**Upgrade:** • Regional subs. to 66 kV and main cities to 220 kV • 25 added interconnections between cities • 400 kV interconnections w. neighboring countries[3]	**Basic upgrade enabling yearly additions of:** 1,000 MW Solar 50 MW Wind 500 MW CSP 1,000 NG	**Smart grid enabling yearly additions of:** 2,000 MW Solar 100 MW Wind 500 MW CSP 2,000 NG
Barges availability	**Maintained at 385 MW to 2030**	**Increased to 825 MW by 2020 and retired in 2022**	**Maintained at 385 MW and retired in 2022**	**Maintained at 385 MW and retired in 2022**

1) Land requirements are assumed to be 60 MW / Km² for solar PV, 3 MW / Km² for wind and 30 MW / Km² for CSP; 2) CIP Plan assumes capital projects are finalized as per the plan's approved dates;
3) Includes Syria, Jordan, Egypt, Turkey
Note: All analysis developed based on LNG gas prices of 10 $/mmBTU;
Source: Team Analysis

"Leapfrog RE" increases the share of solar PV and wind in the generation mix from 2% to 39%, leading to significant benefits

2030 Generation Mix

TWh



	Do Nothing	CIP Plan	Green Transition	Leapfrog RE
2030 Capacity (GW)	6.6	5.6	8.0	10.7

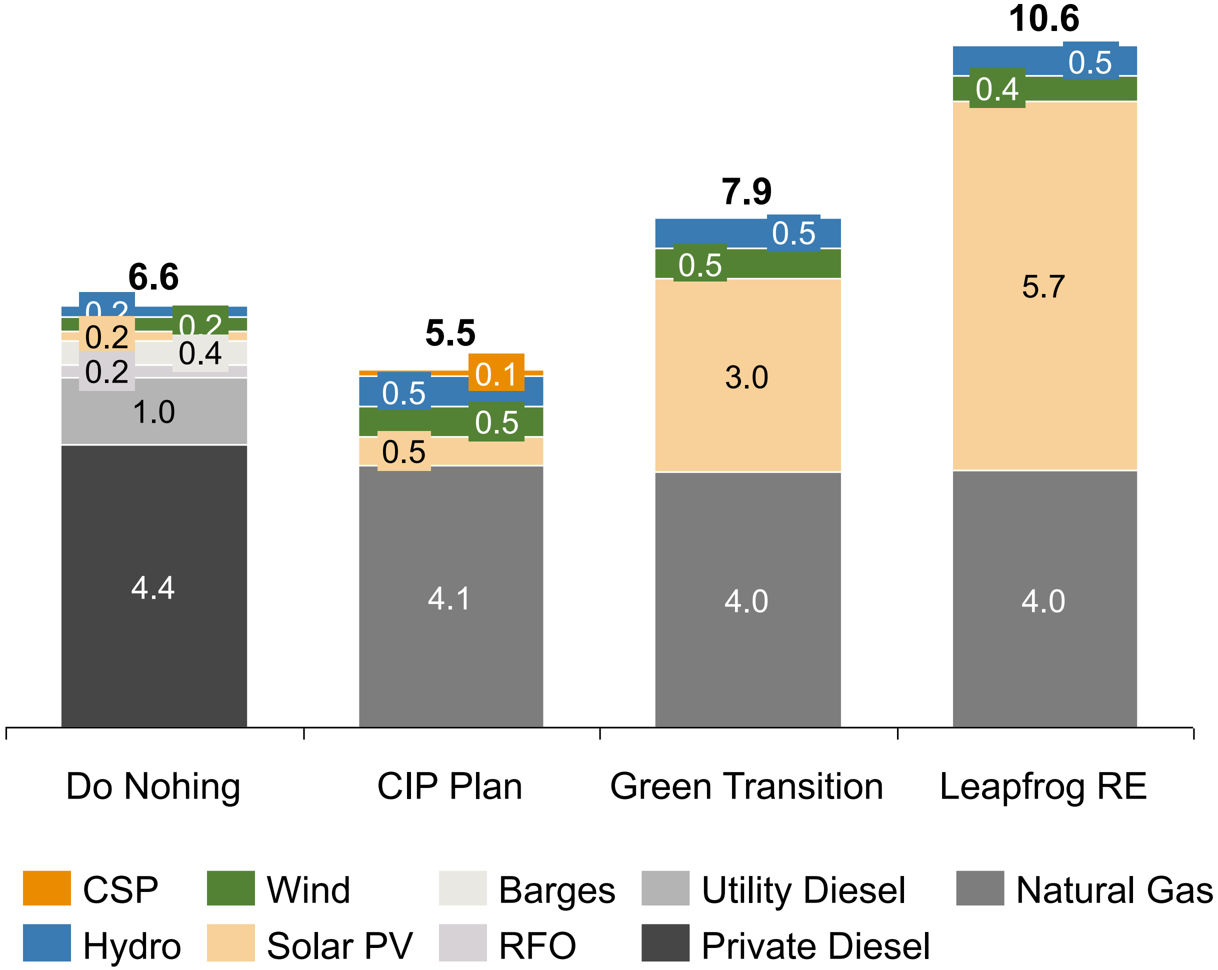
	Do Nothing	CIP Plan	Green Transition	Leapfrog RE
'19-'30 NPV of LCOEs[1] (cents / KWh)	35.8	19.2	18.0	16.0
Net savings[2] (Bn USD)		+ 30.3	+ 32.4	+ 36.1
Liquid fuels displacement (Year)		2029	2025	2023
EDL fuel savings[3] (Bn USD)		- 1.1	+1.0	+2.1
GHG reduction[4] (%)		- 44%	- 53%	- 61%
Job creation (FTEs)	~5,100	~1,200	~1,900	~2,700
Local value add[5] (%)		- 2%	+ 4%	+ 15%

1) LCOE expected to reach 35.8 cents/KWh under a "Do Nothing" scenario; 2) Net savings compared to "Do Nothing" in Bn USD: CIP Plan (30.3); Green Transition (32.4); Leapfrog RE (36.1); 3) Fuel savings compared to "Do Nothing" in Bn USD: CIP Plan (-1.1); Green Transition (1.0); Leapfrog RE (2.1); 4) GHG Reduction compared to "Do Nothing": CIP Plan (-44%); Green Transition (-53%); Leapfrog RE (-61%); 5) Localized spending assumed to be 100% for EPC, 5-10% for machinery and equipment, and 100% for operational non-fuel O&M

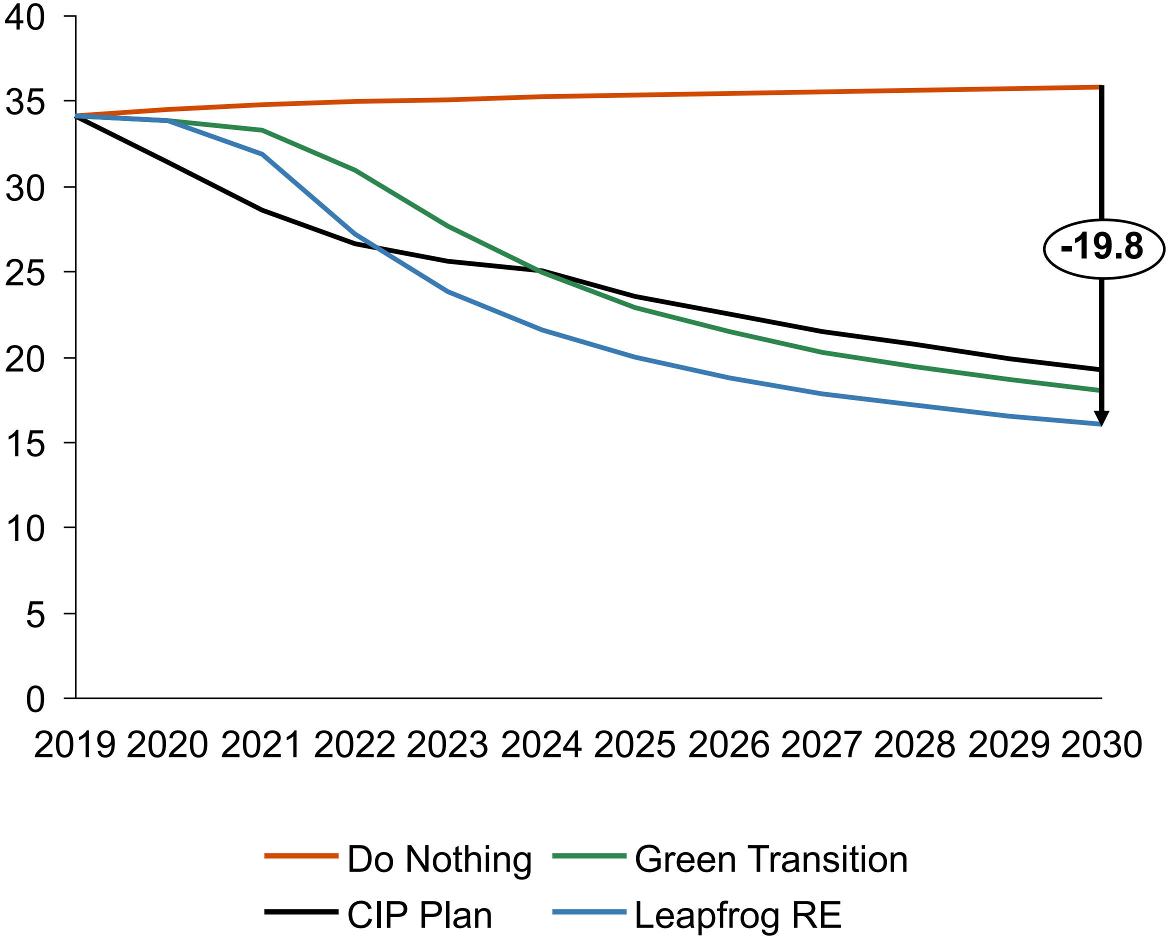
Source: Team Analysis

"Leapfrog RE" installs 6.1 GW of solar PV and wind by 2030 reducing the LCOE by ~20 c/kWh compared to "Do Nothing"

2030 Cumulative Capacity
GW



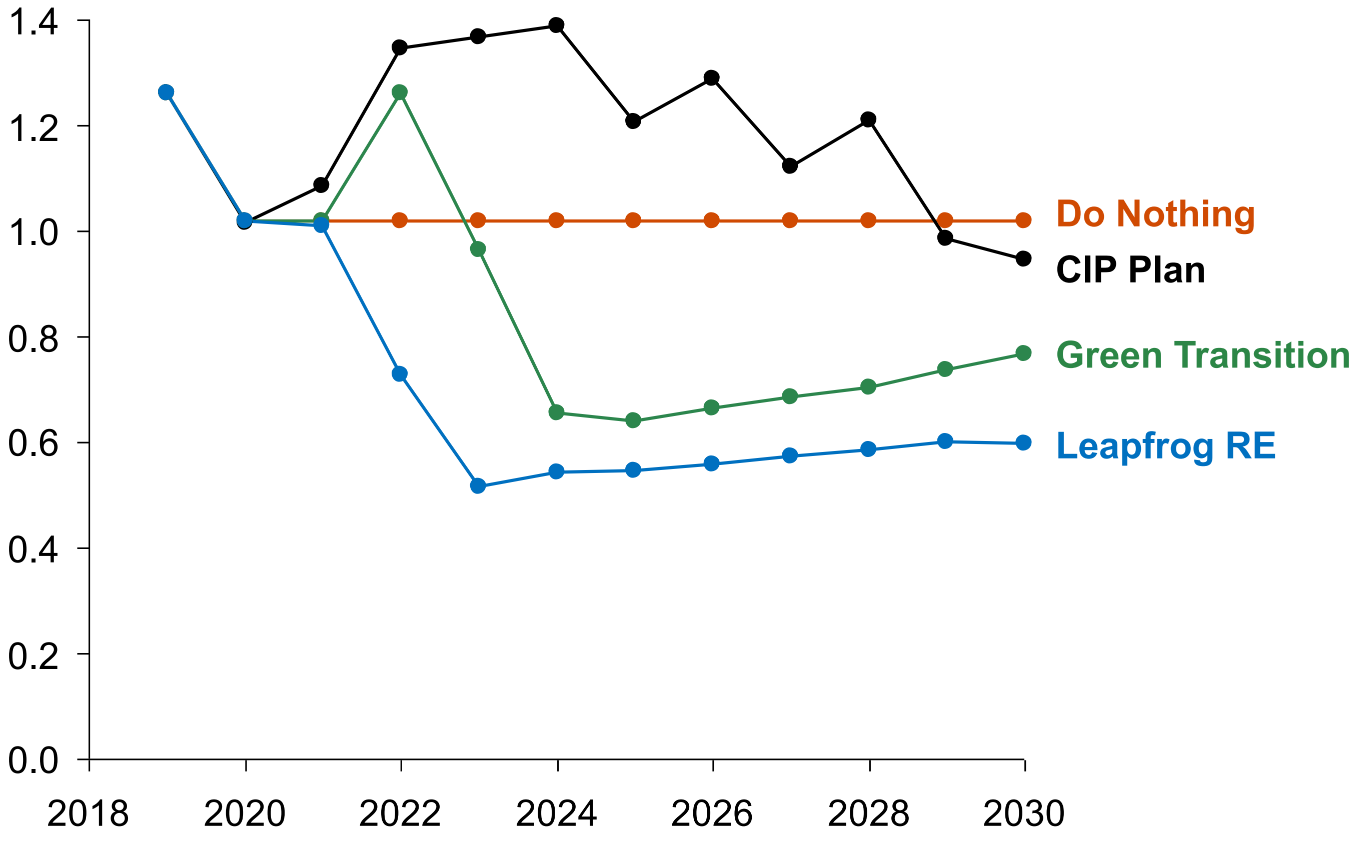
Levelized Cost of Electricity
NPV, 2019 US cents / KWh



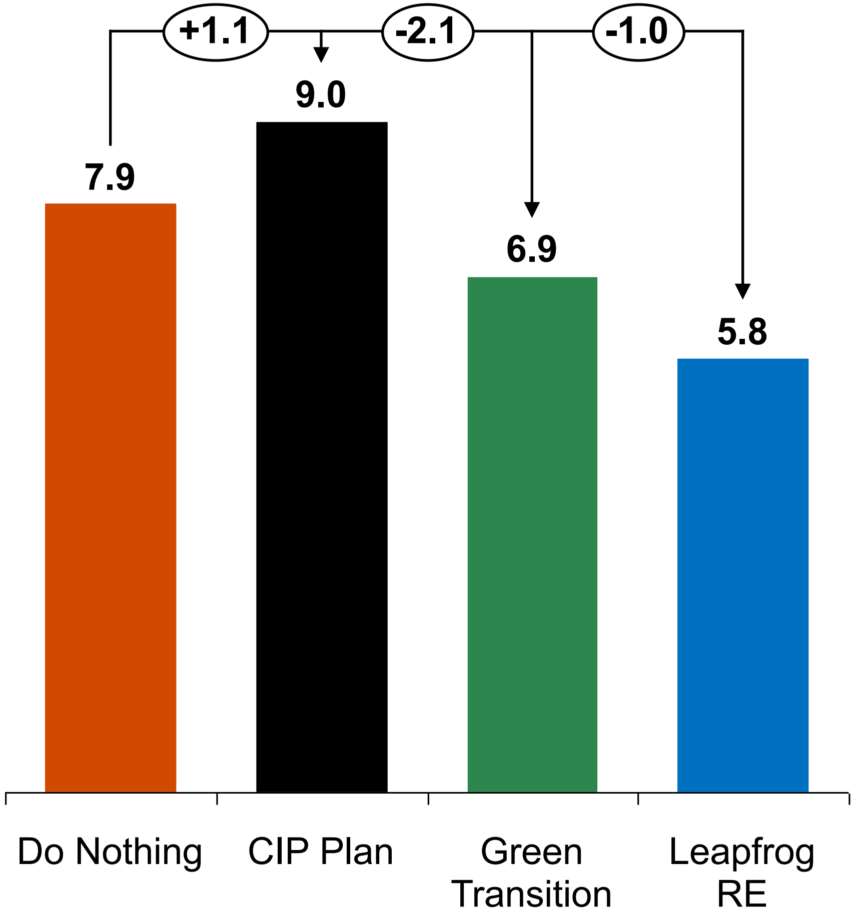
Source: Team Analysis

This translates into savings of ~USD 2.1 Bn in fuel cost between 2019 and 2030

Annual Fuel Cost[1]
Bn USD



Cumulative Fuel Cost[1]
2019 – 2030, Bn USD

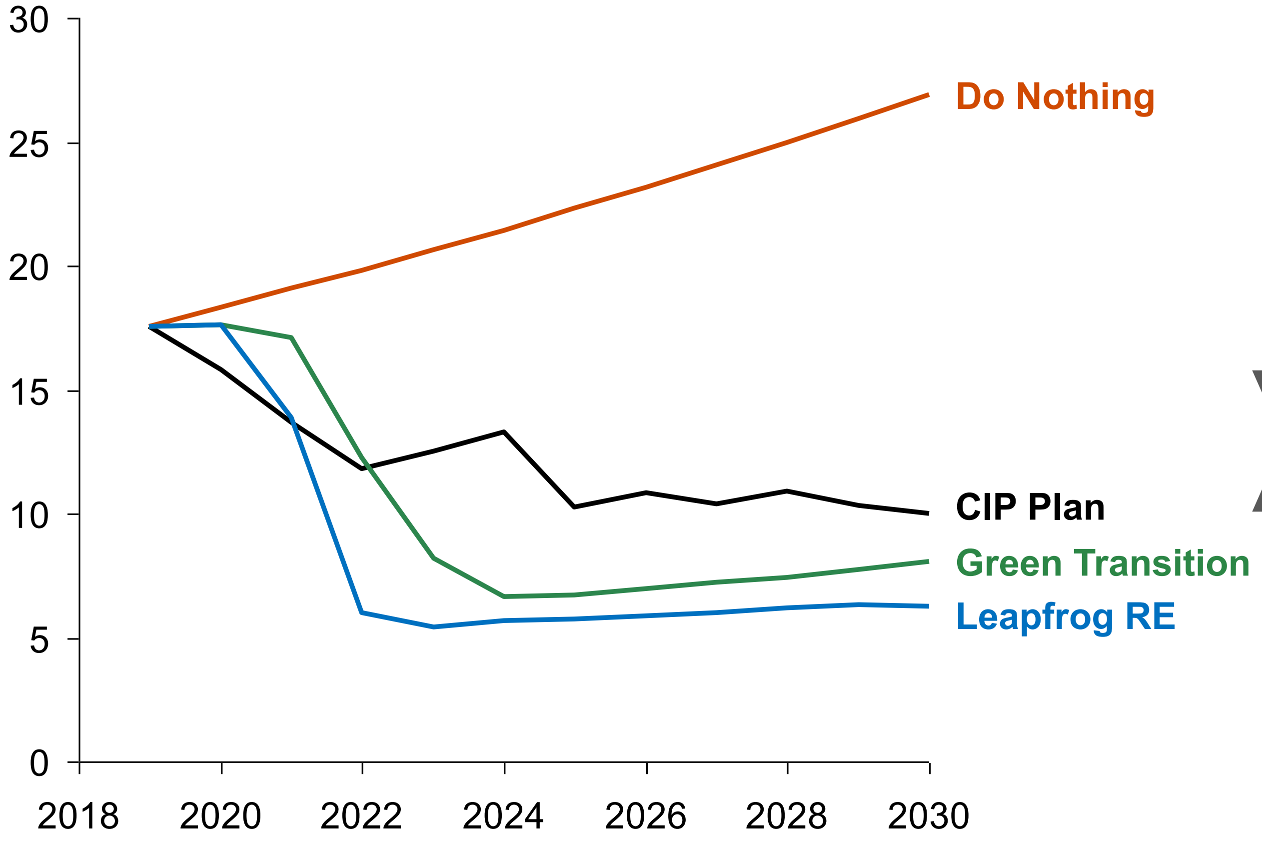


1) Calculated at fixed prices for each type of fuel in USD / mmBtu: NG (11), RFO (32), Diesel (42)
Source: Team Analysis

In addition, “Leapfrog RE” reduces greenhouse gas emissions by 61% compared to the “Do Nothing” scenario

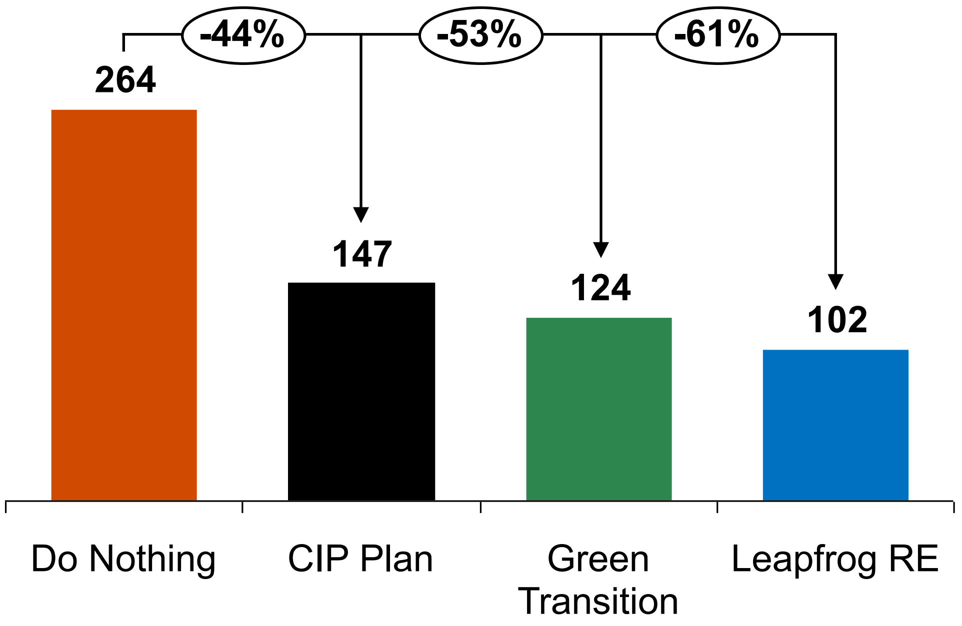
Yearly Greenhouse Gas Emissions[1]

Mn Tons of CO_2 Equivalent



Total Greenhouse Gas Emissions

Mn Tons of CO_2 Equivalent, (2019 – 2030)



Avoided Healthcare Costs

NPV USD Bn, (2019 – 2030)

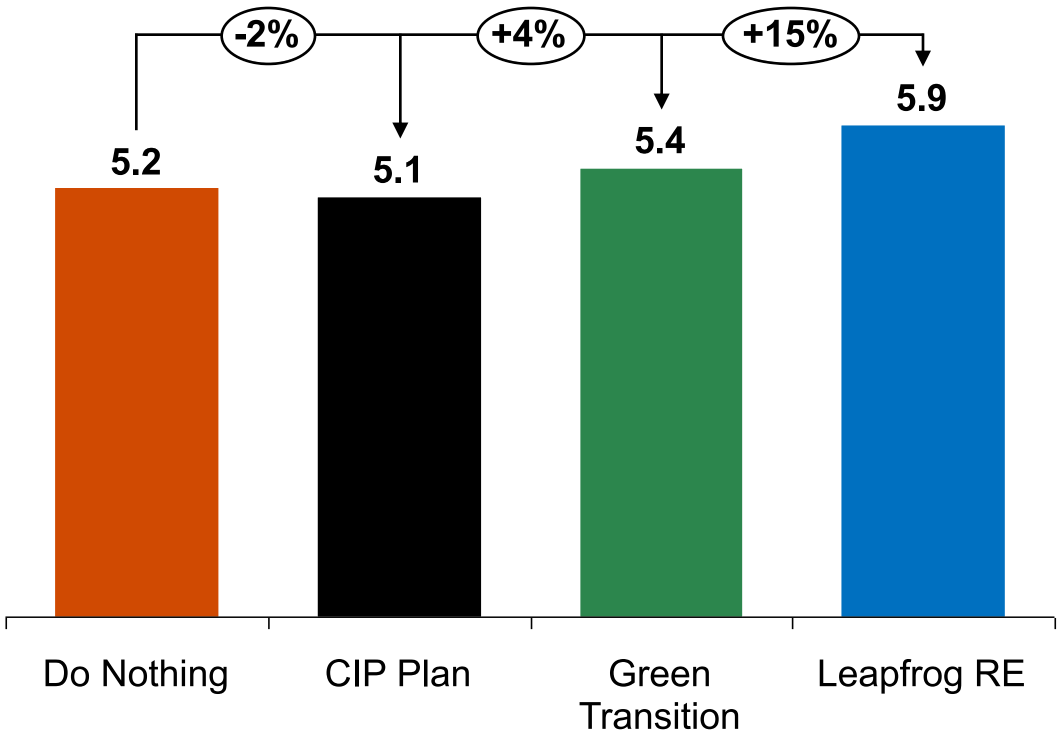
Do Nothing	CIP Plan	Green Transition	Leapfrog RE
-	4.6	5.4	6.4

1) Greenhouse gas emissions include water vapor, carbon dioxide (CO2), methane (CH4), sulfur oxide (SOx), Nitrogen oxide (NOx) and others; Operational emissions of renewable energy are considered negligible while for conventional energy the values in Kg of CO2 / MWh are: Natural Gas (399); Residual Fuel Oil (700); Diesel fuel (700); Diesel Distributed Generators (1143)

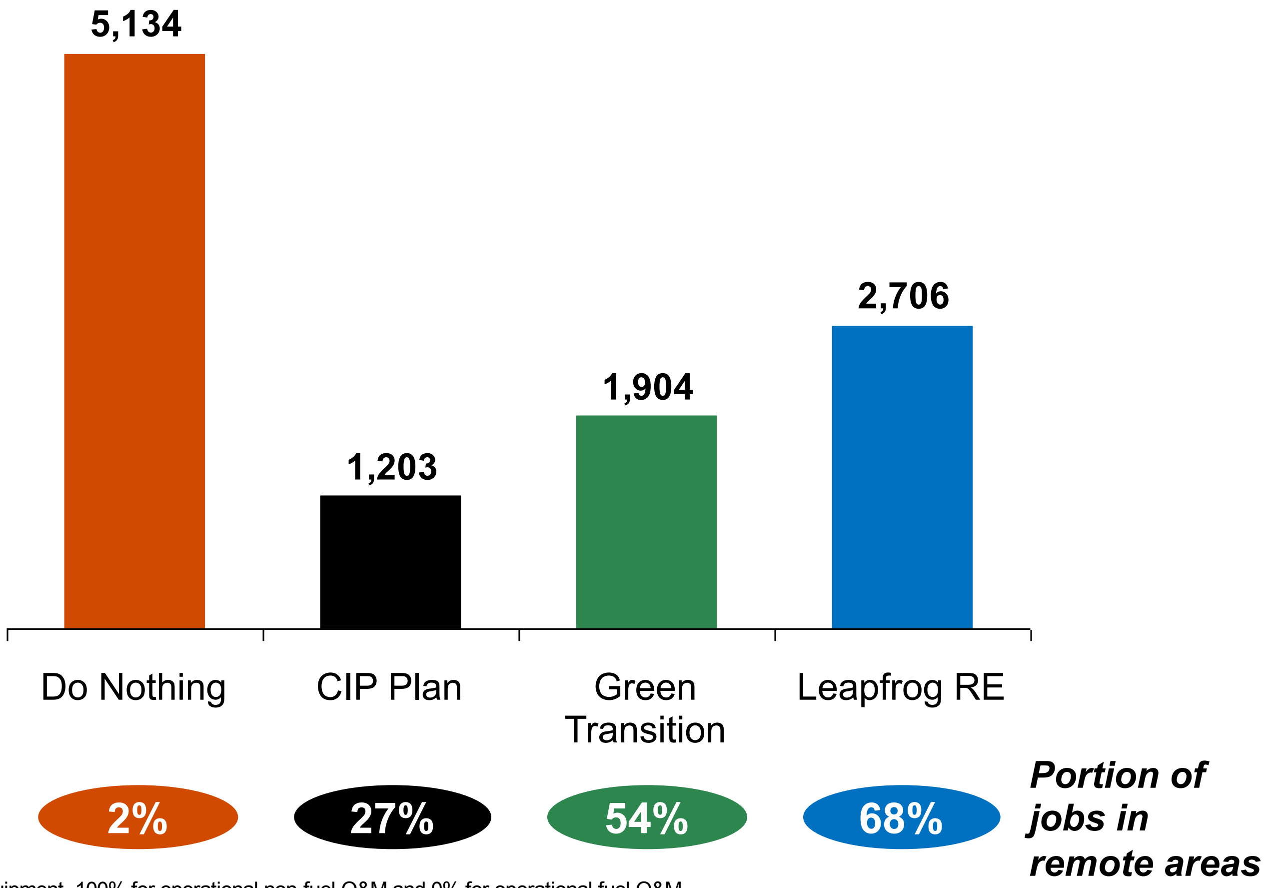
Source: Team Analysis

"Leapfrog RE" offers the highest impact on GDP and the highest number of sustainable jobs in remote areas

Local Value Add[1]
2019 Bn USD



Sustainable Job Creation[2] in 2030
FTEs



1) Localized spending is assumed to be 100% for EPC, 5-10% for machinery and equipment, 100% for operational non-fuel O&M and 0% for operational fuel O&M
2) Operations and Maintenance jobs created in FTE/MW: Wind (0.3); Hydro (0.3); PV (0.3); CSP (0.5); Barges (0.0); Conventional (0.14); Diesel Generators (6.33)
Source: Team Analysis

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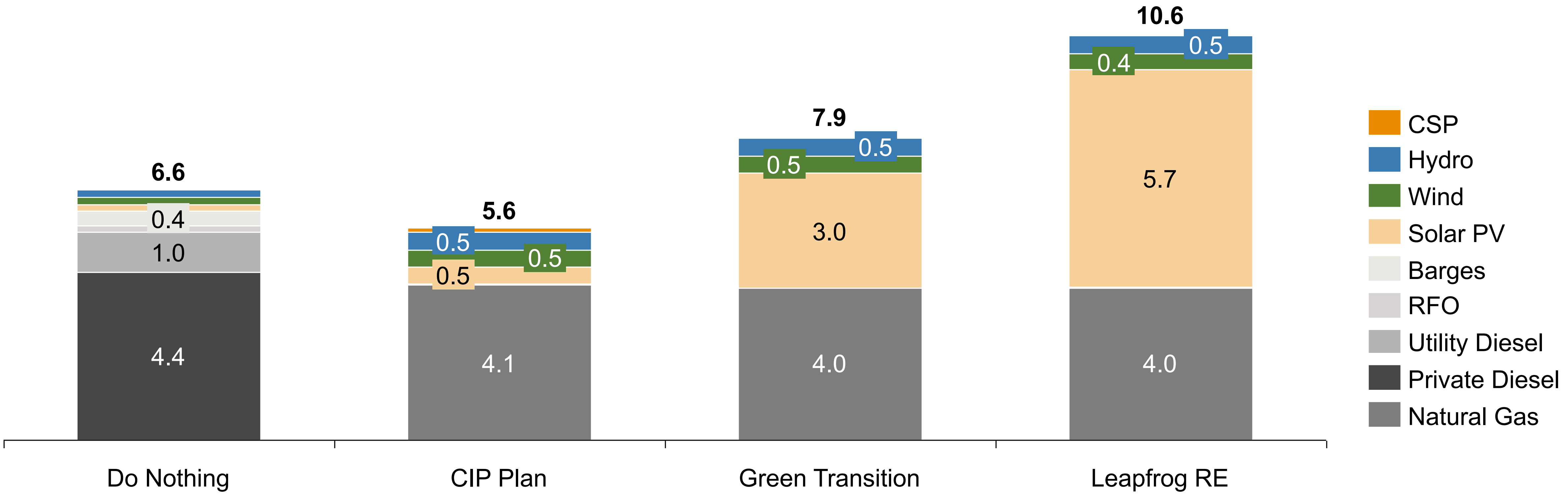
To realize "Leapfrog RE" benefits, Lebanon should install 5.7 GW of Solar PV, 0.4 GW of Wind and 0.5 GW of Hydro

2030 capacity mix GW

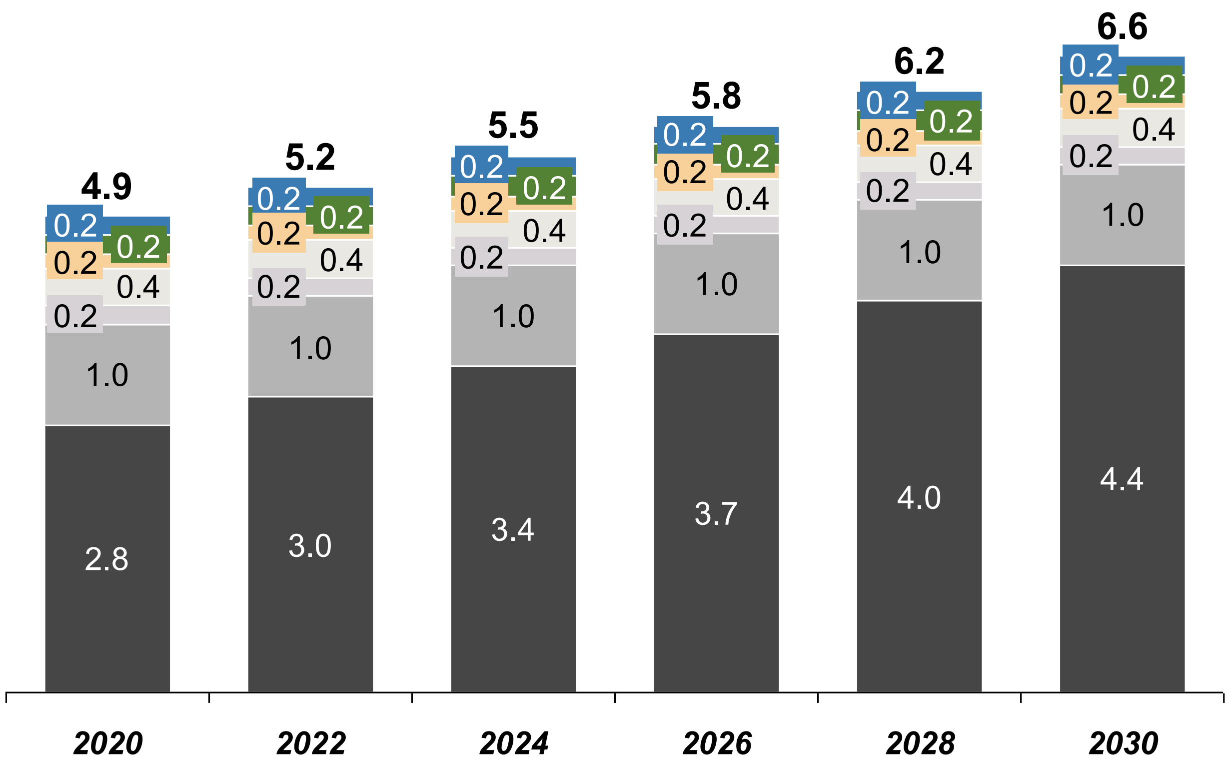


Do Nothing	CIP Plan	Green Transition	Leapfrog RE	
~2,096	***~3,625***	***~5,501***	***~7,178***	***CAPEX[1]*** *USD Mn*

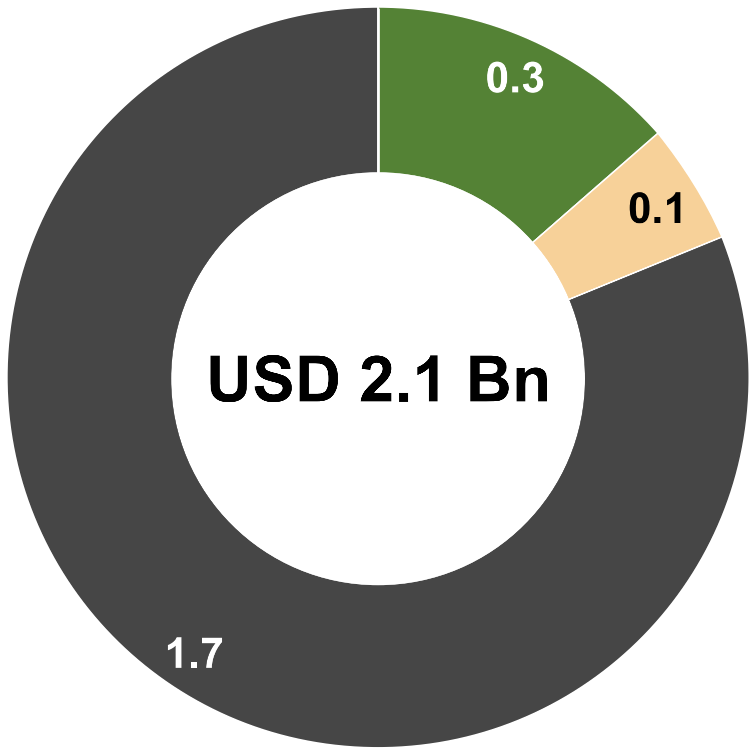
1) CapEx payments are NPV'ed at a discount factor of 10%
Source: Team Analysis

Do Nothing Scenario

Capacity Ramp Up
GW



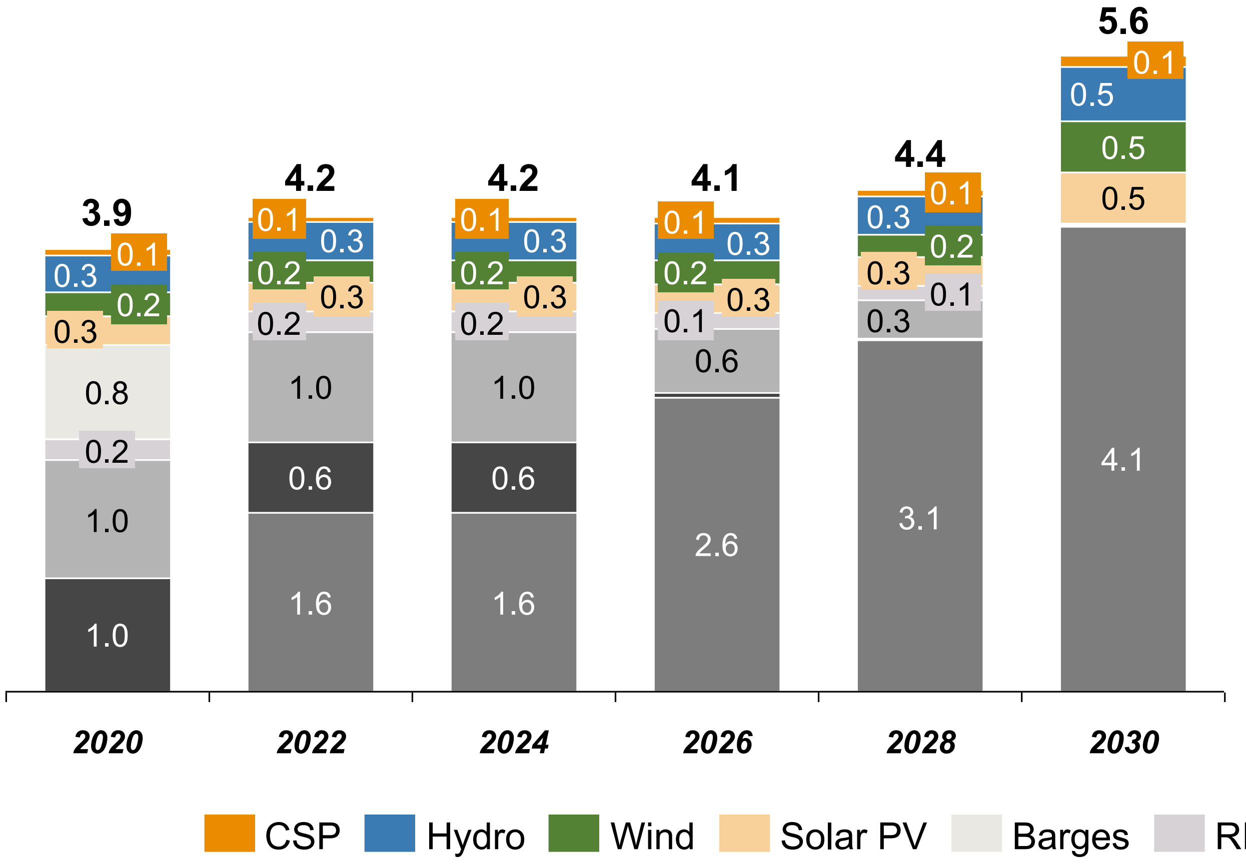
Cumulative CapEx[1]
By 2030, USD Bn



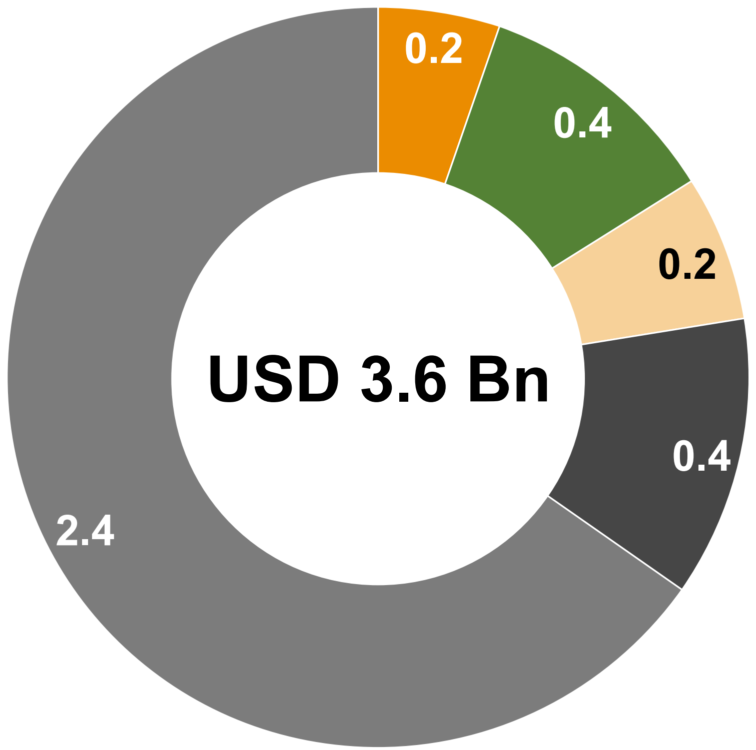
1) CapEx payments are NPV'ed at a discount factor of 10%
Source: Team Analysis

CIP Plan

Capacity Ramp Up
GW



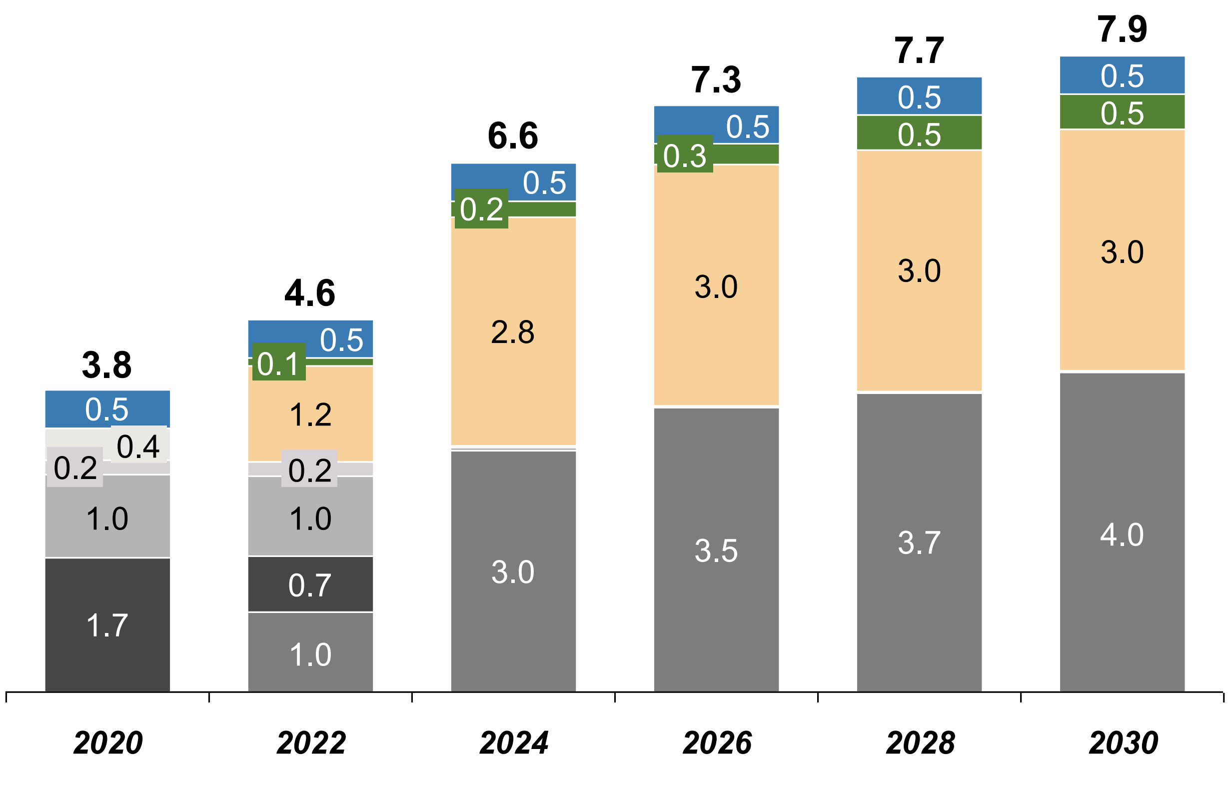
Cumulative CapEx[1]
By 2030, USD Bn



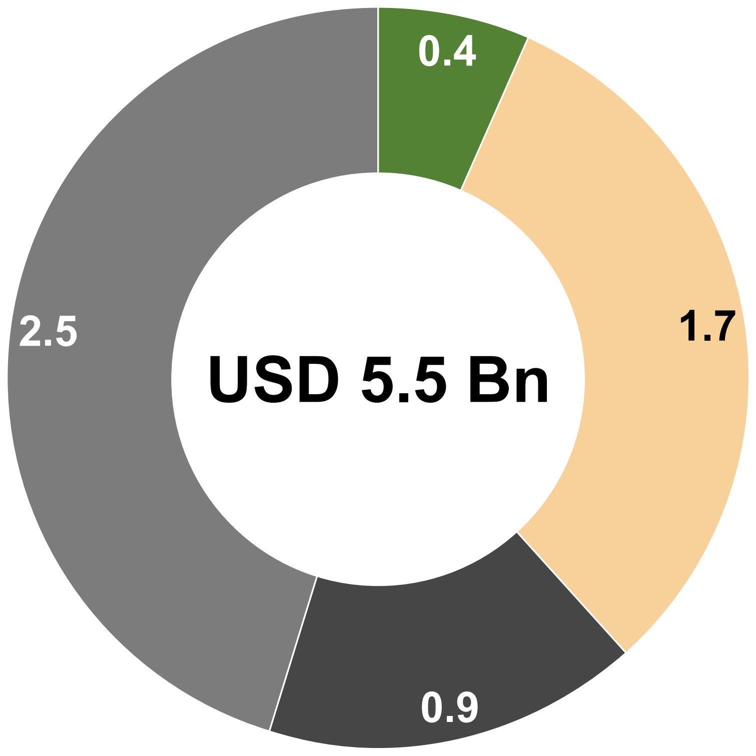
1) CapEx payments are NPV'ed at a discount factor of 10%
Source: Team Analysis

Green Transition

Capacity Ramp Up
GW



Cumulative CapEx[1]
By 2030, USD Bn

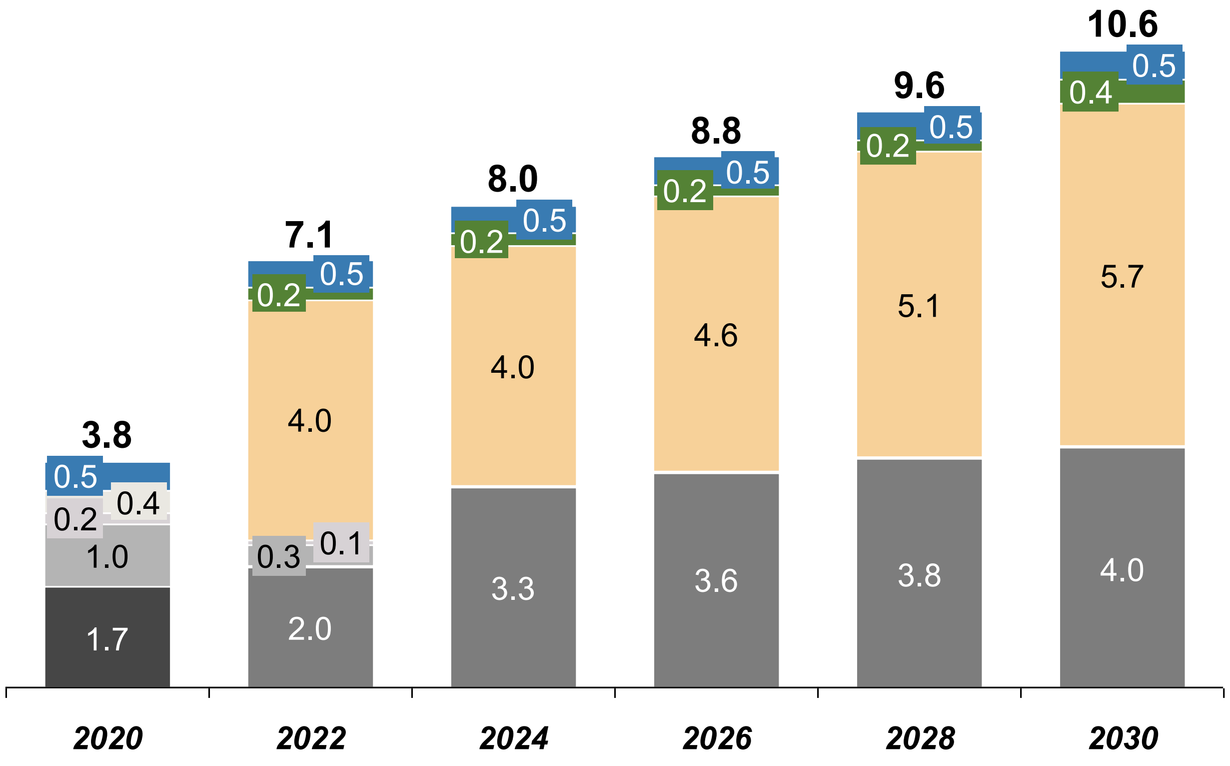


CSP | Hydro | Wind | Solar PV | Barges | RFO | Utility Diesel | Private Diesel | Natural Gas

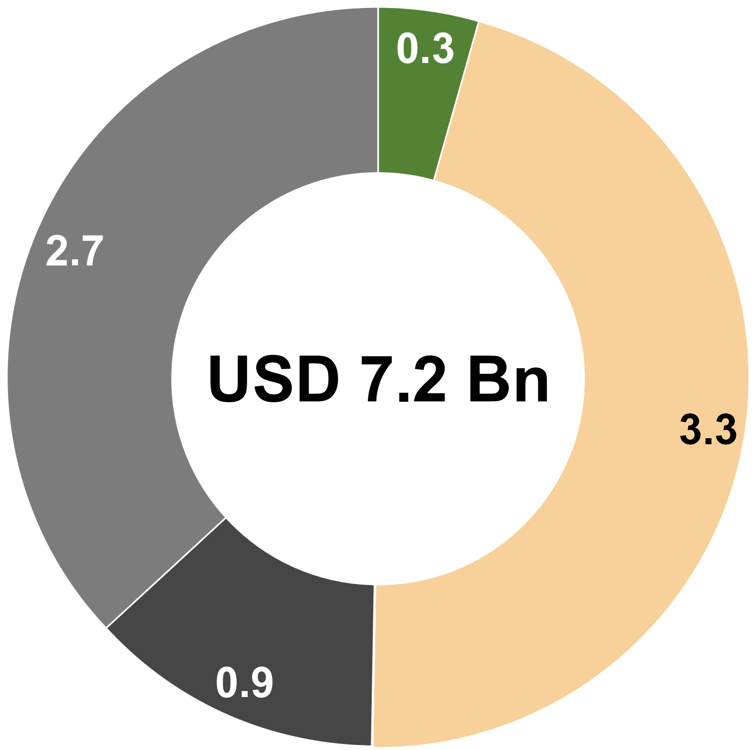
1) CapEx payments are NPV'ed at a discount factor of 10%
Source: Team Analysis

Leapfrog RE

Capacity Ramp Up
GW



Cumulative CapEx[1]
By 2030, USD Bn



CSP | Hydro | Wind | Solar PV | Barges | RFO | Utility Diesel | Private Diesel | Natural Gas

1) CapEx payments are NPV'ed at a discount factor of 10%
Source: Team Analysis

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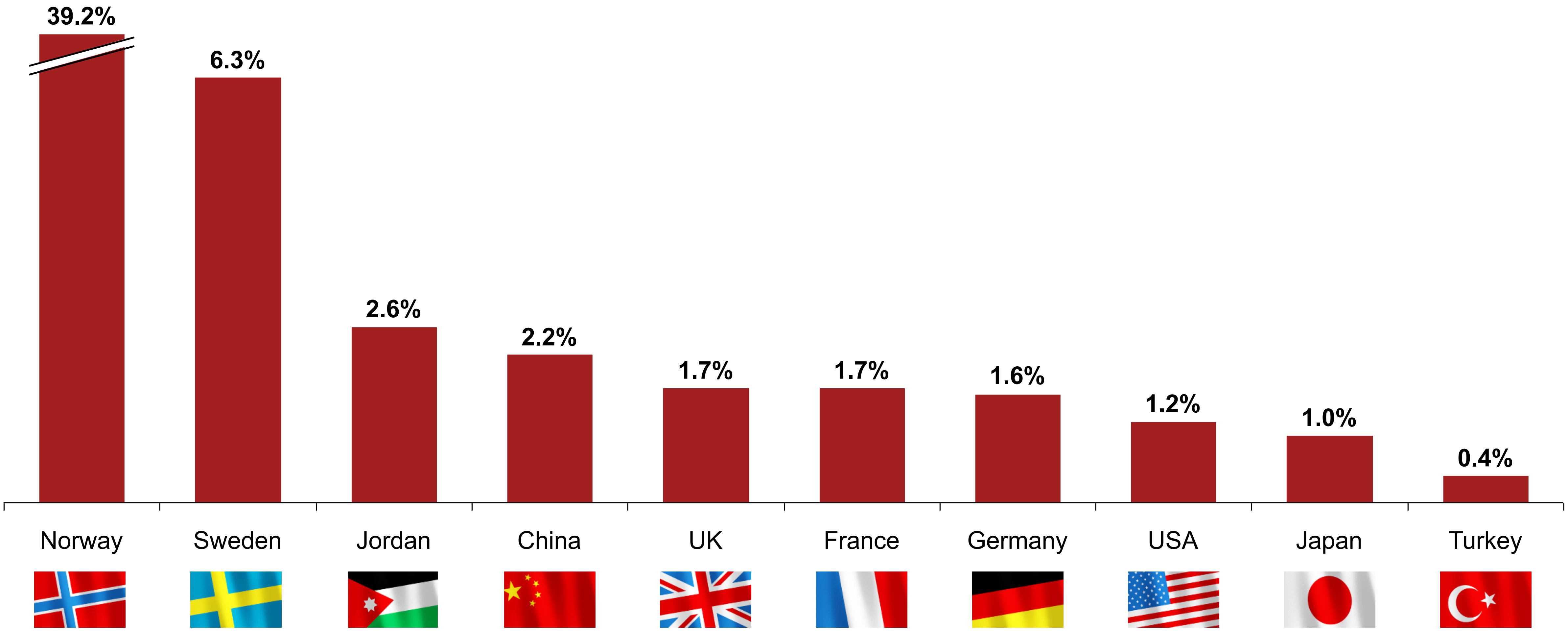
EV penetration by country – 2017



Source: OECD,IEA

Job creation ratios by technology FTE/MW

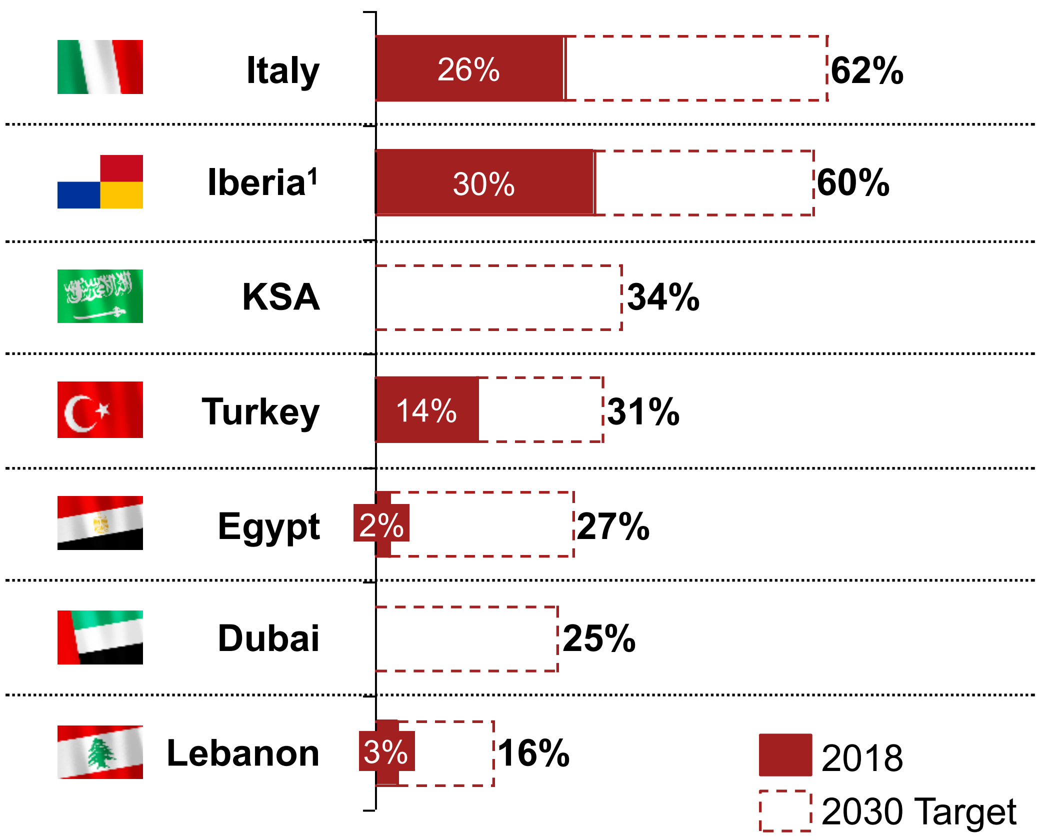
Capacities in GW (Excl. Gas)	Manufacturing			Eng. And construction			O&M		
	>1.5	0.5 to 1.5	0 to 0.5	>0.6	0.2 to 0.6	0 to 0.2	>0.6	0.2 to 0.6	0 to 0.2
PV	3.8*	4.4*	5.0*	2.0		5.0[a]	0.1	0.2	0.3
CSP[a]	4.0	8.0	12.8	6.0	8.0	10.2	0.2	0.3	0.5
Wind[a]	2.0	3.0	4.0	1.7		2.0	0.1	0.2	0.3
W2E		N/A			7			0.9 to 1.1	
Gas[c]		0.93			1.3			0.14	

*) FTE/MW: Polysilicon (0.1; 0.2; 0.2); Wafer (0.9; 1.0; 1.1); Cells (0.40; 0.50; 0.7); Modules (1.4; 1.5; 1.7); Inverters (1.2; 1.2; 1.3)
Source: IRENA, Institute for Sustainable Futures, 6 W2E Facilities in the USA, Columbia University

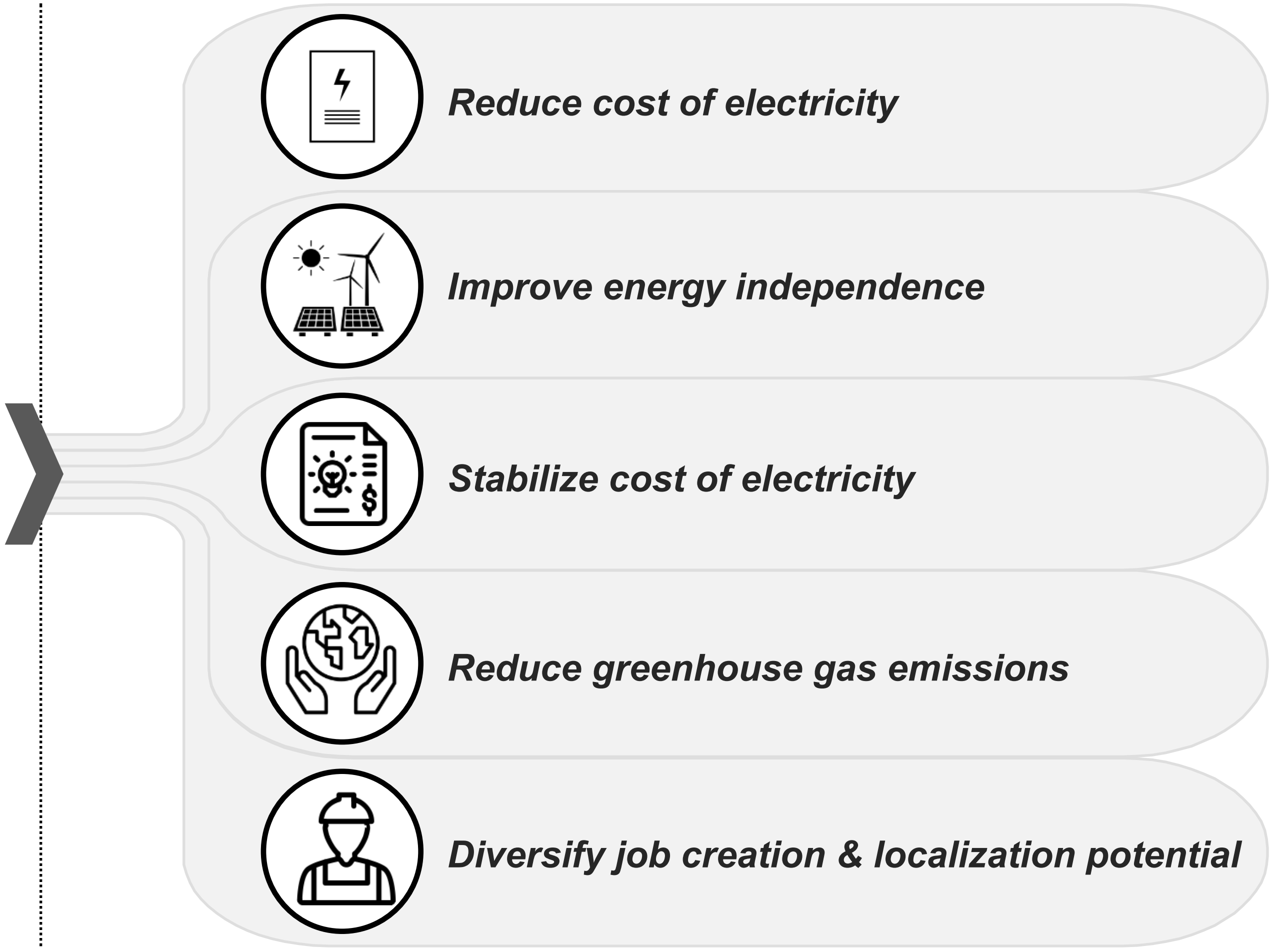
In comparison with other regional countries, Lebanon’s aspirations for solar and wind energy tend to be conservative

Energy Mix Share of Solar and Wind

Mediterranean and GCC Area, % of GW



Advantages of Renewable Energy



1) Iberia includes the countries of Portugal, Spain, British Crown colony of Gibraltar and Andorra

Source: Team Analysis