Centre for Energy Finance

Investment Sizing India's 2070 Net-Zero Target

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Executive summary

On 1 November 2021, India's Prime Minister declared that India would achieve net-zero emissions by 2070. The announcement made at COP26 in Glasgow was in tandem with a declaration of an enhancement of India's Paris commitments. Achieving net-zero involves technology pathways as well as financial flows. These finance flows, or investments, are required to fund the construction of the associated physical infrastructure (**total investment**). In India's case, such investments will run into trillions of dollars. The investment requirement curve would have been steeper if the time taken to reach net-zero was to be reduced further. The mobilisation of investments to achieve net-zero expectedly will be sourced from domestic banks, Non-Banking Finance Companies (NBFC), and debt capital markets, both domestic and international. However, a gap remains (**investment gap**) between the total investment required to achieve net-zero and the amount that can be reasonably mustered from conventional sources.

> Along with the sectoral deployment of different technologies, India's net-zero commitment will require immense capital investment in infrastructure.

Table 1 Total investment, gap, and support for India's net-zero target scenarios

	Total investment		Investment gap		Investment support	
	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*
2040 peak - 2070 net-zero	10,103	*202*	3,546	*71*	1,419	*28*
2030 peak - 2060 net-zero	8,266	*207*	4,181	*105*	1,672	*42*
2030 peak - 2050 net-zero	5,724	*191*	3,407	*114*	1,363	*45*

Source: CEEW-CEF analysis

Note: Amounts in constant 2020 USD billion

Bridging this gap requires investment from overseas, which may be sought on concessional terms. For purposes of this brief, we assume the concession to be the cost of hedging, irrespective of whether the capital flows as equity or debt[1]. The value of the concession represents the real value of external investment support (**investment support**) required for achieving net-zero. In table 1, we size these three investment types for three net-zero scenarios for India, including the declared 2070 target. Specifically, the total investment estimated pertains to electricity (generation, integration, transmission, and distribution), hydrogen (production), and vehicles (manufacturing). We find that the aggregate investment support required by India to achieve its 2070 net-zero target will be USD 1.4 trillion at an average of USD 28 billion per year.

To mobilise USD 10.1 trillion of investments and bridge the investment gap of USD 3.5 trillion, under the 2070 net-zero pathway, India would need investment support worth USD 1.4 trillion until 2070. This investment support amount equates to an average annual value of USD 28 billion over the next 50 years, varying from USD 8 billion annually in the first decade, to USD 42 billion annually in the fifth decade.

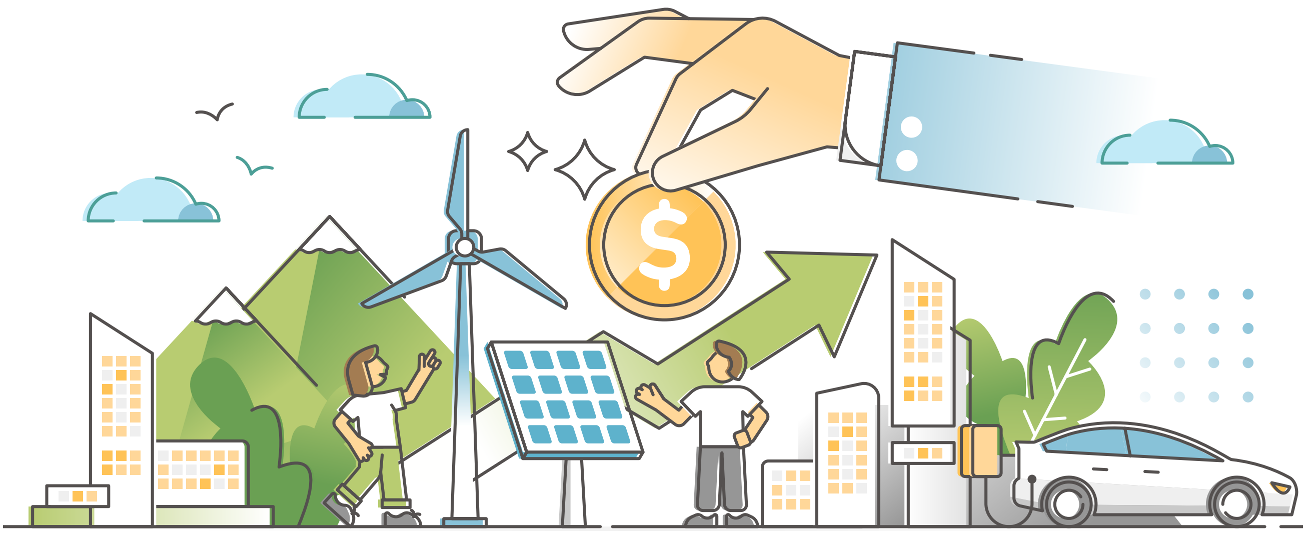

Image: iStock

1. Currency hedge is a kind of insurance against unfavourable movements in exchange rates between the capital source and deployment country. The cost of this insurance refers to the cost of hedging. We have considered the hedging cost as the value of investment support required to attract private capital to the identified sector beyond the conventional sources.

Table 2 Investment gap per decade for India's 2070 net-zero target

	2040 peak - 2070 net-zero		2040 peak -2060 net-zero		2030 peak -2050 net-zero	
	Aggregate	*Average annual*	Aggregate	*Average annual*	Aggregate	*Average annual*
2020-30 (decade 1)	82	*8*	85	*9*	90	*9*
2030-40 (decade 2)	122	*12*	405	*40*	471	*47*
2040-50 (decade 3)	352	*35*	547	*55*	801	*80*
2050-60 (decade 4)	442	*44*	635	*64*	-	-
2060-70 (decade 5)	420	*42*	-	-	-	-
Aggregate from 2020 till the respective net-zero year	1,419	-	1,672	-	1,363	-
Average annual from 2020 till the respective net-zero year	-	*28*	-	*42*	-	*45*

Source: CEEW-CEF analysis

Note: Amounts in constant 2020 USD billion

However, as table 2 demonstrates, the decadal investment support requirements are not flat but rather increase significantly as we near respective net-zero years. Had India chosen a 2050 net-zero target year, the average annual investment support requirements in decades two and three (USD 47bn and USD 80bn respectively) would have been 3.9x and 2.3x the corresponding values for the 2070 target year selected.

1. Introduction

Developing countries looking beyond conventional means to secure investments could look for support beyond their borders. They have long demanded that developed nations increase commitments towards climate finance. A number of developed nations have responded by enhancing climate finance pledges in the months leading up to COP26 and during the conference (UNCCC UK. 2021). The hope on this front is a further increase in ambition beyond the USD 100 billion and that actual flows eventually match the promises made. Further, the finalisation of the implementation guidelines relating to carbon markets under Article 6 at COP26, including the settlement of the long-standing issue of the transition of certified emission reductions (CERs) from the Kyoto Protocol regime (Dutt, Arjun. 2021), potentially offers new possibilities for channelling investment flows.

But the biggest promise lies in the USD 130 trillion in collective assets managed by banks, insurers, asset managers, and asset owners, all of whom have committed to achieve net-zero emissions by 2050 and stay on a 1.5°C pathway (UNEP,2021 and GFANZ,2021). This is an unprecedented opportunity for India's excellent long-term policy certainty, and zero emission investment needs to match the tsunami of capital committed to global decarbonisation opportunities.

So what explains the appeal of net-zero targets? What would achieving them for a country like India would entail?

> **Net-zero commitments by developing countries will require international banks, insurers, asset managers managing USD 130 trillion in collective assets to deliver on their pledges. Investment support measures can play a critical role in ensuring this capital flows as required.**

2. Net-zero's appeal

Net-zero's appeal lies in its simplicity. It means gross emissions are matched by carbon sinks that can fully absorb them. These can be natural sinks, such as forests or soil carbon sequestration. They can also be man-made and achieved through technologies such as carbon capture and storage (CCS)—although almost no progress has been made to date on CCS despite two decades of promises from the fossil fuel industry (IEA,2020). In effect, net-zero does away with the subjective parameters in various NDCs, such as the choice of base year or the choice between reductions in total emissions and reductions in emissions intensity. It simplifies the debate around emissions using a common yardstick.

Even so, two questions remain. First, what does net-zero look like? Second, how much investment does it require? Both are vital to understanding the one variable in an otherwise uniform yardstick: the year by which a country can reasonably hope to achieve net-zero. However, to assess the feasibility of any net-zero target year, it is critical to fully appreciate the physical infrastructure needed as well as the associated financial requirements.

3. What does net-zero look like?

On 12 October 2021, CEEW released a working paper titled *Implications of a Net-Zero Target for India's Sectoral Energy Transitions and Climate Policy* (Chaturvedi, Vaibhav, and Ankur Malyan. 2021). It uses the Global Change Analysis Model (GCAM, CEEW version) to generate sixteen sectoral pathways, or scenarios, under which India could achieve net-zero. It then evaluates these scenarios against a reference scenario. Each scenario is a distinct combination of two variables: the choice of peaking and net-zero years, and the degree of availability of two technologies (CCS and green hydrogen). Table 3 summarises the sixteen scenarios.

The scenarios generated by the model demonstrate how five key sectors—power, transport, industrial, building, and refinery—would need to evolve to cumulatively achieve net-zero. Under each scenario, and for each sector, the pathways generated comprise a combination of sectoral interventions. Table 4 highlights the interventions considered for new investment calculations in this issue brief.

Table 3 The 16 scenarios

	Carbon capture & storage No	Carbon capture & storage Yes
Hydrogen Low	2030 (peak) – 2050 (net-zero)	2030 (peak) – 2050 (net-zero)
	2030 – 2060	2030 – 2060
	2040 – 2070	2040 – 2070
	2050 – 2080	2050 – 2080
Hydrogen High	**2030 – 2050**	2030 – 2050
	2030 – 2060	2030 – 2060
	2040 – 2070	2040 – 2070
	2050 – 2080	2050 – 2080

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Note: For purposes of this issue brief, we have evaluated the four scenarios represented in the bottom left quadrant. The rationale: (a) limited visibility at present on commercial viability and costs for CCS technologies; (b) deep decarbonisation will require high hydrogen penetration in the absence of CCS.

Table 4 Sectoral interventions under each net-zero scenario

	Interventions considered for new investment	Interventions not considered for new investment
Power	• Quantity (units) of power generated by 13 generation types (solar, wind, etc). The supporting transmission and distribution, RE integration network required to supply the electricity.	
Transport	• Volumes of 6 types (2W, 3W, 4W etc) of vehicles manufactured across EV, H_2 and liquids and associated manufacturing capacities.	
Industrial	• Volume of H_2 (tonnes) produced for industrial energy (heat and feedstock) and H_2 powered vehicles and associated manufacturing capacities.	• Peak year for coal use, reduction in its use beyond peak year. • Reduction in industrial energy intensity of GDP.
Building		• Reduction in intensity of electricity use with respect to GDP.
Refinery		• Peak year for crude oil consumption, reduction in its use beyond peak year.

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

4. From interventions to investments

How do we connect the dots from the required sectoral interventions to the quantum of investment needed to achieve them? Table 5 outlines the approach we used to arrive at our investment sizing assumptions. We provide details of the model-generated interventions considered for new investments under each of the selected scenarios in Annexure 1. Details of investment sizing assumptions, which remain the same across scenarios, are in Annexure 2.

Table 5 Model output & investment sizing assumptions

	Model generated output		Investment sizing assumptions
	Interventions considered for new investment	Associated interventions	
Power	• Quantity (units) of power generated by 13 generation types (solar, wind, etc).	• GW capacity for each of the 13 generation types (solar, wind, etc).	• Investment required per MW capacity for each generation type in constant 2020 USD '000. And the supporting transmission and distribution, RE integration network required to supply the electricity.
Transport	• Volumes of 6 types (2W, 3W, 4W etc) of vehicle sold across EV, H_2 and liquids.		• Investment required per vehicle type per million manufacturing capacity in constant 2020 USD '000 (Excludes investment in the development of charging infrastructure).
Industrial	• Volume of H_2 (tonnes) produced for industrial energy (heat and feedstock) and H_2 powered vehicles.		• Investment required per kg of H_2 production capacity in constant 2020 USD '000.

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

5. Investment sizing

We quantified total investment, investment gap, and investment support (as defined later) for the selected 2070 and the other scenarios. Table 6 provides a sector-wise breakdown until the respective net-zero year under the 2070 and other net-zero scenarios and the reference progress as usual scenario *(until 2070)*. We provide details of total investment at a decade level in Annexure 3. Details of the methodology we used to arrive at our investment gap and investment support figures for the power and industrial sectors are in Annexure 4 and Annexure 5, respectively.

a) **Total investment**: The total capital that needs to be invested in physical infrastructure to achieve the net-zero scenario.

b) **Investment gap**: The gap between the total investment and what the banking, NBFC, and capital markets are able to muster.

c) **Investment support**: The support required to mobilise finance that bridges the investment gap.

Table 6 Quantifying the investments

	Total investment		Investment gap		Investment support	
	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*	Aggregate from 2020 till the respective net-zero year	*Average annual from 2020 till the respective net-zero year*
Power	8,412	*168*	3,098	62	1,239	25
Mobility	198	*4*	--	--	-	--
Industrial	1,494	*30*	448	9	179	*4*
Total 2040 peak - 2070 net-zero	**10,103**	***202***	**3,546**	***709***	**1,419**	***28***
Power	6,865	*172*	3,799	95	1,520	*38*
Mobility	128	3	--	--	--	--
Industrial	1,273	32	382	*10*	153	*4*
Total 2030 peak - 2060 net-zero	**8,266**	***207***	**4,181**	***105***	**1,672**	***42***
Power	4,854	*162*	3,168	*106*	1,267	*42*
Mobility	71	2	--	--	--	--
Industrial	799	*27*	240	*8*	96	*3*
Total 2030 peak - 2050 net-zero	**5,724**	***191***	**3,407**	***114***	**1,363**	***45***
Power	9,751	*163*	1,252	*21*	501	*8*
Mobility	277	5	--	--	--	--
Industrial	1,866	*31*	560	*9*	224	*4*
Total 2050 peak - 2080 net-zero	**11,894**	***198***	**1,812**	***30***	**725**	***12***
Power (until 2070)	4,523	*90*	497	*10*	199	*4*
Mobility (until 2070)	202	*4*	--	*0*	--	--
Industrial (until 2070)	15	*0*	5	*10*	2	*0*
Total Reference (until 2070)	**4,741**	***95***	**501**	***10***	**200**	***4***

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Note: Amounts in constant 2020 USD billion

Annexure I Model-generated outputs

Table A1 Model generated outputs under Reference PAU scenario

Reference		2020	2040	2050	2070	2080
Power (aggregate generating capacity GW)						
Solar		40	552	796	1,274	1,638
Wind		38	215	286	412	496
Coal		202	306	385	463	457
Hydro		45	61	73	96	108
Nuclear		6	24	38	77	93
All other		15	52	58	73	68
Total		346	1,209	1,636	2,395	2,860
Mobility (annual vehicle sales in millions)						
4W	Electric	0.01	5.28	11.23	19.13	21.41
	H_2	0.00	0.00	0.00	0.00	0.00
	Liquids	1.44	2.45	2.35	3.37	3.58
	NG	0.07	1.31	1.71	3.43	4.14
2W	Electric	0.75	18.53	16.67	9.12	6.87
	Liquids	18.23	4.50	1.65	0.84	0.64
3W	Electric	0.01	0.43	0.22	0.07	0.04
	Liquids	0.64	0.04	0.01	0.00	0.00
	NG	0.16	0.04	0.01	0.00	0.00
Bus	Electric	0.00	0.00	0.00	0.00	0.00
	Liquids	0.02	0.00	0.00	0.00	0.00
	NG	0.00	0.00	0.00	0.00	0.00
Trucks	Electric	0.00	0.00	0.01	0.08	0.19
	H_2	0.00	0.00	0.00	0.00	0.00
	Liquids	0.20	0.87	0.92	1.00	0.96
	NG	0.00	0.38	0.63	1.57	1.77
Liquids vehicles		20.52	7.86	4.92	5.21	5.18
Other vehicles (Elec, NG and H_2)		1.00	25.99	30.49	33.41	34.44
Total vehicles		21.52	33.85	35.42	38.62	39.61
Hydrogen (Production, million tonnes)						
Annual production (million tonnes)		0	2.13	4.39	7.70	9.06

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Table A2 **Model generated outputs under 2050 peak - 2080 net-zero scenario**

2050 peak – 2080 net-zero		2020	2040	2050	2070	2080
Power (aggregate generating capacity GW)						
Solar		40	547	780	3,965	6,414
Wind		38	213	281	1,267	1,911
Coal		202	320	409	6	0
Hydro		45	61	73	96	108
Nuclear		6	23	36	157	221
All other		15	40	31	23	6
Total		346	1,205	1,610	5,515	8,660
Mobility (annual vehicle sales in millions)						
4W	Electric	0.01	5.28	8.15	19.87	24.31
	H_2	0.00	0.00	0.01	0.25	1.08
	Liquids	1.44	2.45	2.34	2.79	1.74
	NG	0.07	1.32	1.72	3.18	2.65
2W	Electric	0.75	18.51	16.67	9.75	7.48
	Liquids	18.23	4.50	1.66	0.34	0.02
3W	Electric	0.01	0.43	0.22	0.07	0.05
	Liquids	0.64	0.04	0.01	0.00	0.00
	NG	0.16	0.04	0.01	0.00	0.00
Bus	Electric	0.00	0.00	0.00	0.00	0.00
	Liquids	0.02	0.00	0.00	0.00	0.00
	NG	0.00	0.00	0.00	0.00	0.00
Trucks	Electric	0.00	0.00	0.02	0.90	2.17
	H_2	0.00	0.00	0.00	0.31	0.83
	Liquids	0.20	0.87	0.89	0.17	0.00
	NG	0.00	0.40	0.66	0.62	0.00
Liquids vehicles		20.52	7.86	4.90	3.30	1.76
Other vehicles (Elec, NG and H_2)		1.00	25.98	27.46	34.95	38.58
Total vehicles		21.52	33.84	32.36	38.25	40.34
Hydrogen (Production, million tonnes)						
Annual production (million tonnes)		0	7.29	27.64	75.84	128.72

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Table A3 **Model generated outputs under 2040 peak - 2070 net-zero scenario**

2040 peak – 2070 net-zero		2020	2040	2050	2070	2080
Power (aggregate generating capacity GW)						
Solar		40	540	1,689	5,631	6,462
Wind		38	211	558	1,793	1,950
Coal		202	335	169	0	0
Hydro		45	61	73	96	108
Nuclear		6	23	69	226	272
All other		15	35	53	8	6
Total		346	1,205	2,611	7,753	8,797
Mobility (annual vehicle sales in millions)						
4W	Electric	0.01	5.28	8.24	22.41	24.09
	H_2	0.00	0.00	0.01	0.28	1.07
	Liquids	1.44	2.45	2.20	1.70	1.76
	NG	0.07	1.31	1.67	2.25	2.78
2W	Electric	0.75	18.49	17.20	9.91	7.48
	Liquids	18.23	4.52	1.18	0.02	0.02
3W	Electric	0.01	0.43	0.24	0.07	0.05
	Liquids	0.64	0.04	0.00	0.00	0.00
	NG	0.16	0.04	0.00	0.00	0.00
Bus	Electric	0.00	0.00	0.00	0.00	0.00
	Liquids	0.02	0.00	0.00	0.00	0.00
	NG	0.00	0.00	0.00	0.00	0.00
Trucks	Electric	0.00	0.00	0.02	1.92	2.32
	H_2	0.00	0.00	0.01	0.52	0.90
	Liquids	0.20	0.87	0.70	0.00	0.00
	NG	0.00	0.39	0.59	0.00	0.00
Liquids vehicles		20.52	7.88	4.09	1.73	1.78
Other vehicles (Elec, NG and H_2)		1.00	25.96	27.99	37.37	38.70
Total vehicles		21.52	33.84	32.08	39.10	40.48
Hydrogen (Production, million tonnes)						
Annual production (million tonnes)		0	7.18	40.14	114.48	134.84

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Table A4 Model generated outputs under 2030 peak - 2060 net-zero scenario

2030 peak – 2060 net-zero		2020	2040	2050	2070	2080
Power (aggregate generating capacity GW)						
Coal		202	104	2	0	0
Hydro		46	61	73	96	108
Nuclear		7	52	116	268	319
Others		37	79	33	8	7
Solar		40	1,360	2,985	5,687	6,342
Wind		38	489	1,001	1,806	1,894
Total		370	2,145	4,209	7,865	8,670
Mobility (annual vehicle sales in millions)						
4W	Electric	0.01	5.47	8.48	22.29	24.07
	H_2	0.00	0.00	0.01	0.28	1.07
	Liquids	1.44	2.31	1.85	1.70	1.73
	NG	0.07	1.29	1.52	2.31	2.79
2W	Electric	0.75	20.26	18.47	10.00	7.54
	Liquids	18.23	3.26	0.45	0.02	0.02
3W	Electric	0.01	0.49	0.25	0.07	0.05
	Liquids	0.64	0.01	0.00	0.00	0.00
	NG	0.16	0.02	0.00	0.00	0.00
Bus	Electric	0.00	0.01	0.01	0.00	0.00
	Liquids	0.02	0.00	0.00	0.00	0.00
	NG	0.00	0.00	0.00	0.00	0.00
Trucks	Electric	0.00	0.00	0.36	2.07	2.11
	H_2	0.00	0.00	0.15	0.57	0.82
	Liquids	0.20	0.70	0.18	0.00	0.00
	NG	0.00	0.35	0.16	0.00	0.00
Liquids vehicles		20.52	6.29	2.47	1.72	1.75
Other vehicles (Elec, NG and H_2)		1.00	27.88	29.41	37.59	38.45
Total vehicles		21.52	34.17	31.88	39.31	40.21
Hydrogen (Production, million tonnes)						
Annual production (million tonnes)		0	9.87	56.67	120.14	134.77

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Table A5 Model generated outputs under 2030 peak - 2050 net-zero scenario

2030 peak – 2050 net-zero		2020	2040	2050	2070	2080
Power (aggregate generating capacity GW)						
Coal		202	65	0	0	0
Hydro		46	61	73	96	108
Nuclear		7	62	167	310	368
Others		37	61	15	9	6
Solar		40	1,657	4,559	6,470	7,105
Wind		38	595	1,500	2,041	2,128
Total		370	2,501	6,314	8,926	9,714
Mobility (annual vehicle sales in millions)						
4W	Electric	0.01	5.47	8.82	22.27	24.02
	H_2	0.00	0.00	0.01	0.28	1.07
	Liquids	1.44	2.30	1.23	1.68	1.76
	NG	0.07	1.28	1.14	2.32	2.81
2W	Electric	0.75	20.10	18.13	9.79	7.41
	Liquids	18.23	3.17	0.04	0.02	0.02
3W	Electric	0.01	0.50	0.24	0.07	0.05
	Liquids	0.64	0.01	0.00	0.00	0.00
	NG	0.16	0.01	0.00	0.00	0.00
Bus	Electric	0.00	0.01	0.01	0.00	0.00
	Liquids	0.02	0.00	0.00	0.00	0.00
	NG	0.00	0.00	0.00	0.00	0.00
Trucks	Electric	0.00	0.00	1.40	2.00	2.23
	H_2	0.00	0.00	0.33	0.55	0.87
	Liquids	0.20	0.71	0.00	0.00	0.00
	NG	0.00	0.32	0.00	0.00	0.00
Liquids vehicles			20.52	6.19	1.28	1.70
Other vehicles (Elec, NG and H_2)			1.00	27.69	30.09	37.29
Total vehicles			21.52	33.89	31.36	38.99
Hydrogen (Production, million tonnes)						
Annual production (million tonnes)		0	10.21	62.40	119.97	134.88

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Annexure II Investment sizing assumptions

Table A6 Investment sizing assumptions used for the reference and analysed net-zero scenarios

Common assumptions for reference and four net-zero scenarios	2020	2040	2050	2070	2080
Power (constant 2020 USD 000 per MW)					
Solar[a]	400	280	270	270	270
Wind[a]	979	903	867	816	816
Coal (IGCC)[a]	-	1,723	1,723	1,723	1,723
Nuclear (Gen III)[a]	3,851	3,851	3,851	3,851	3,851
RE integration[b]		51 to 72	63 to 88	63 to 88	63 to 88
Distribution[c]	USD 64/MWh				
Transmission[d]	USD 91/MWh				
Mobility (constant 2020 USD million manufacturing capacity cost per million production for all technologies)					
4W[e]	232				
2W[e]	11.76				
3W[e]	9.95				
Bus[e]	394				
Truck[e]	394				
Hydrogen (constant 2020 USD investment required per kg of hydrogen production capacity with a 25 year life)					
Solar-based[f]	29.8	15.3	9.76	9.76	9.76
Wind-based[f]	42.6	24.3	21.61	21.61	21.61
Grid-based[f]	15	8.1	4.54	4.54	4.54

Source: CEEW-CEF analysis and compilation based on Chaturvedi, Vaibhav, and Ankur Malyan. 2021. Implications of a net-zero target for India's sectoral energy transitions and climate policy. New Delhi: Council on Energy, Environment and Water.

Note:

(a) The per MW cost estimates of solar, wind and coal deployment, nuclear are based on a CEEW-CEF compilation and market research; for hydro, we have used the IIT-Roorkee estimates of costs (IIT-Roorkee, 2015). Costs for all other technologies are also considered, but not depicted above given their relatively minor contribution to investment requirements.

(b) The integration cost is assumed to be USD 43-63 for 1 KW of solar and USD 60-78 for 1KW of wind capacity deployed from 2026 onwards.

(c) The distribution investment requirement assumes an annual investment of INR 0.19/unit based on the gross assets deployed at the national level from 2017 to 2020, based on the PFC report on the performance of state power utilities in 2020 and 2019 (PFC, 2021, 2020, 2021). ((INR 0.19 x 1000)/(73 INR/USD)) x 25 years life = USD 64/MWh.

(d) The transmission investment requirement is taken to be INR 0.27/unit of electricity supplied annually for the period of analysis. The charge is equivalent to 31 per cent of the transmission charges of the INR 0.85/unit transmission charges in FY20 as per the report, *Analysis of Factors Impacting Retail Tariff and Measures to Address Them*, by the Forum of Regulators. ((INR 0.27 x 1000)/(73 INR/USD)) x 25 years life = USD 91/MWh.

(e) The EV benchmark investment costs for producing per million vehicles have been derived using the balance sheets of prominent players in the respective segments and the methodology described in the CEEW report, *Financing India's Transition to Electric Vehicles* (Singh, Vaibhav et al. 2020). The fixed costs (including R&D) and the annual production capacity have been used to derive the benchmarks, and the depreciation has been used to approximate the useful life of the assets.

(f) The investments related to hydrogen are based on estimates as under the CEEW report titled "A Green Hydrogen Economy for India: Policy and Technology Imperatives to Lower Production Cost" (Biswas, Tirtha, Deepak Yadav and Ashish Guhan.2020.). The hydrogen numbers are assumed constant post 2050.

Annexure III Total investment

Table A7 Total investments needed for power, mobility and hydrogen under different scenarios

(i) Reference	2020-30	2030-40	2040-50	2050-60	2060-70	2070-80	Total
Power							
Generation	*382*	*538*	*526*	*685*	*674*	*715*	***3,520***
Integration	*8*	*26*	*33*	*49*	*54*	*66*	***236***
T&D	*133*	*220*	*318*	*402*	*476*	*542*	***2,091***
Power Total	**523**	**783**	**876**	**1,136**	**1,205**	**1,323**	**5,846**
Mobility	13	25	40	56	69	78	**281**
Hydrogen	1	2	3	4	6	7	**22**
Total	**537**	**810**	**919**	**1,195**	**1,279**	**1,408**	**6,149**
(ii) 2050 peak – 2080 net-zero							
Power							
Generation	*380*	*547*	*502*	*1,290*	*1,705*	*1,898*	***6,321***
Integration	*8*	*25*	*32*	*137*	*216*	*273*	***691***
T&D	*132*	*221*	*317*	*432*	*620*	*1,015*	***2,739***
Power Total	**520**	**794**	**851**	**1,859**	**2,541**	**3,185**	**9,751**
Mobility	13	25	36	54	67	81	**277**
Hydrogen	9	62	237	266	408	885	**1,866**
Total	**542**	**881**	**1,124**	**2,180**	**3,016**	**4,151**	**11,894**
(iii) 2040 peak – 2070 net-zero							
Power							
Generation	*380*	*560*	*1,144*	*1,648*	*1,954*	*1,458*	***7,144***
Integration	*8*	*25*	*112*	*196*	*264*	*211*	***815***
T&D	*132*	*223*	*346*	*525*	*895*	*1,146*	***3,268***
Power Total	**520**	**808**	**1,602**	**2,369**	**3,113**	**2,815**	**11,227**
Mobility	13	25	35	54	70	80	**277**
Hydrogen	9	59	421	386	619	578	**2,071**
Total	**542**	**893**	**2,057**	**2,809**	**3,802**	**3,473**	**13,575**
(iv) 2030 peak – 2060 net-zero							
Power							
Generation	*390*	*1,164*	*1,455*	*1,819*	*1,594*	*1,639*	***8,060***
Integration	*8*	*86*	*158*	*232*	*218*	*239*	***940***
T&D	*132*	*241*	*429*	*752*	*1,006*	*1,156*	***3,716***
Power Total	**530**	**1,490**	**2,043**	**2,802**	**2,818**	**3,034**	**12,716**
Mobility	13	24	34	57	69	80	**277**
Hydrogen	9	137	574	554	391	835	**2,500**
Total	**552**	**1,651**	**2,650**	**3,413**	**3,278**	**3,948**	**15,493**
(v) 2030 peak – 2050 net-zero							
Power							
Generation	*400*	*1,305*	*1,910*	*1,284*	*1,772*	*1,609*	***8,280***
Integration	*10*	*101*	*226*	*166*	*244*	*234*	***982***
T&D	*32*	*248*	*522*	*831*	*1,014*	*1,155*	***3,902***
Power Total	**542**	**1,654**	**2,657**	**2,281**	**3,030**	**2,999**	**13,163**
Mobility	13	24	34	55	70	80	**276**
Hydrogen	11	145	643	457	474	773	**2,503**
Total	**566**	**1,823**	**3,334**	**2,793**	**3,574**	**3,852**	**15,942**

Source: CEEW-CEF analysis

Note: Amounts in constant 2020 USD billion

Annexure IV Investment gap & support (power sector)

Table A8 Breakdown of investment required, gap and support needed by power sector

(i) Reference		2020-30	2030-40	2040-50	2050-60	2060-70	2070-80	Total
Total investment	(A)	523	783	876	1,136	1,205	1,323	5,846
Less banking/NBFC headroom[a]	(B)	232	379	617	1,005	1,636	2,665	6,534
Less domestic bond market[b] Headroom	(C)	68	111	180	294	478	779	1,909
Less int'l bond market Headroom[c]	(D)	19	31	50	82	133	216	530
Investment gap	E= A-B-C-D	204	263	29	Negative	Negative	Negative	497
Annualised finance requirements	(F)= E/10	20	26	3	Negative	Negative	Negative	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)= 4%*E	8	11	1	Negative	Negative	Negative	
(ii) 2050 peak – 2080 net-zero								
Total investment	(A)	520	794	851	1,859	2,541	3,185	9,751
Less banking/NBFC headroom[a]	(B)	232	379	617	1,005	1,636	2,665	6,534
Less domestic bond market[b] Headroom	(C)	68	111	180	294	478	779	1,909
Less int'l bond market Headroom[c]	(D)	19	31	50	82	133	216	530
Investment gap	E= A-B-C-D	201	274	4	480	294	Negative	1,252
Annualised finance requirements	(F)= E/10	20	27	0	48	29	Negative	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)= 4%*E	8	11	0	19	12	Negative	
(iii) 2040 peak – 2070 net-zero								
Total investment	(A)	520	808	1,602	2,369	3,113	2,815	11,227
Less banking/NBFC headroom[a]	(B)	232	379	617	1,005	1,636	2,665	6,534
Less domestic bond market[b] Headroom	(C)	68	111	180	294	478	779	1,909
Less int'l bond market Headroom[c]	(D)	19	31	50	82	133	216	530
Investment gap	E= A-B-C-D	201	288	755	989	865	Negative	3,098
Annualised finance requirements	(F)= E/10	20	29	75	99	87	Negative	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)= 4%*E	8	12	30	40	35	Negative	
(iv) 2030 peak – 2060 net-zero								
Total investment	(A)	530	1,490	2,043	2,802	2,818	3,034	12,716
Less banking/NBFC headroom[a]	(B)	232	379	617	1,005	1,636	2,665	6,534
Less domestic bond market[b] Headroom	(C)	68	111	180	294	478	779	1,909
Less int'l bond market Headroom[c]	(D)	19	31	50	82	133	216	530
Investment gap	E= A-B-C-D	211	970	1,195	1,422	570	Negative	4,369
Annualised finance requirements	(F)= E/10	21	97	120	142	57	Negative	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)= 4%*E	8	39	48	57	23	Negative	
(v) 2030 peak – 2050 net-zero								
Total investment	(A)	542	1,654	2,657	2,281	3,030	2,999	13,163
Less banking/NBFC headroom[a]	(B)	232	379	617	1,005	1,636	2,665	6,534
Less domestic bond market[b] Headroom	(C)	68	111	180	294	478	779	1,909
Less int'l bond market Headroom[c]	(D)	19	31	50	82	133	216	530
Investment gap	E= A-B-C-D	223	1,135	1,810	901	783	Negative	4,852
Annualised finance requirements	(F)= E/10	22	113	181	90	78	Negative	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)= 4%*E	9	45	72	36	31	Negative	

Source: CEEW-CEF analysis

Note:

a. Total banking/NBFC exposure to the power sector as of March 2020 was estimated to be USD 168 billion (Garg, Shreyas, Rishabh Jain and Gagan Sidhu. 2021). This represents a 8 per cent share of the total loan books of Indian Banks and NBFCs, which was estimated to be USD 2.15 trillion (CRIF High Mark, 2021). Headroom is calculated by applying a 5 per cent annual growth rate to USD 168 billion, and assuming a 6 per cent annual principal repayment factor.

b. The total corporate domestic bond market stood at USD 452 billion as of March 2021 (Source: CRISIL Yearbook on the Indian Debt Market 2021). To derive the power sector's share, we have applied the same 8 per cent share that power sector loans represent of total loan books of Indian Banks and NBFCs. This comes to USD 36 billion. Headroom is calculated by applying a 5 pe cent annual growth rate to USD 36 billion, and assuming a 10 per cent annual principal repayment factor (assumed average remaining life of the loan being refinanced).

c. The base for international bond market flows has been estimated to be USD 10 billion. This is based on 3x of the estimated USD 3.5 billion of international bond capital that flowed into Indian RE from January to June 2021 (Garg, Shreyas, Rishabh Jain and Gagan Sidhu. 2021). Headroom is calculated by applying a 5 per cent annual growth rate to USD 10 billion, and assuming a 10 per cent annual principal repayment factor.

d. Amounts in constant 2020 USD billion.

Annexure V Investment gap & support (industrial sector)

Table A9 Breakdown of investment required, gap and support needed by Industrial sector

		2020-30	2030-40	2040-50	2050-60	2060-70	2070-80	Total
(i) Reference								
Total investment	(A)	1	2	3	4	6	7	22
Less banking/NBFC potential or headroom	(B) =40% *A	0.4	0.8	1.0	1.5	2.3	2.6	9
Less domestic bond market and other sources	(C) = 20%*A	0.2	0.4	0.5	0.8	1.1	1.3	4
Less int'l bond market inflows	(D) =10% *A	0.1	0.2	0.3	0.4	0.6	0.7	2
Investment gap	(E)= A-B-C-D	**0.3**	**0.6**	**0.8**	**1.1**	**1.7**	**2.0**	7
Annualised finance requirements	(F) =E/10	0.03	0.06	0.08	0.11	0.17	0.20	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)=4% *(E)	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	
(ii) 2050 peak – 2080 net-zero								
Total investment	(A)	9	62	237	266	408	885	1,866
Less banking/NBFC potential or headroom	(B) =40% *A	3	25	95	107	163	354	747
Less domestic bond market and other sources	(C) = 20%*A	2	12	47	53	82	177	373
Less int'l bond market inflows	(D) =10% *A	1	6	24	27	41	88	187
Investment gap	(E)= A-B-C-D	**3**	**19**	**71**	**80**	**122**	**265**	560
Annualised finance requirements	(F) =E/10	0	2	7	8	12	27	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)=4% *(E)	**0**	**1**	**3**	**3**	**5**	**11**	
(iii) 2040 peak – 2070 net-zero								
Total investment	(A)	9	59	421	386	619	578	2,071
Less banking/NBFC potential or headroom	(B) =40% *A	3	24	168	154	247	231	828
Less domestic bond market and other sources	(C) = 20%*A	2	12	84	77	124	116	414
Less int'l bond market inflows	(D) =10% *A	1	6	42	39	62	58	207
Investment gap	(E)= A-B-C-D	**3**	**18**	**126**	**116**	**186**	**173**	621
Annualised finance requirements	(F) =E/10	0	2	13	12	19	17	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)=4% *(E)	**0**	**1**	**5**	**5**	**7**	**7**	
(iv) 2030 peak – 2060 net-zero								
Total investment	(A)	9	137	574	554	391	835	2,500
Less Banking/NBFC potential or headroom	(B) =40% *A	4	55	229	222	157	334	1,000
Less domestic bond market and other sources	(C) = 20%*A	2	27	115	111	78	167	500
Less int'l bond market inflows	(D) =10% *A	1	14	57	55	39	84	250
Investment gap	(E)= A-B-C-D	**3**	**41**	**172**	**166**	**117**	**251**	750
Annualised finance requirements	(F) =E/10	0	4	17	17	12	25	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)=4% *(E)	**0**	**2**	**7**	**7**	**5**	**10**	
(v) 2030 peak – 2050 net-zero								
Total investment	(A)	11	145	643	457	474	773	2,503
Less banking/NBFC potential or headroom	(B) =40% *A	4	58	257	183	190	309	1,001
Less domestic bond market and other sources	(C) = 20%*A	2	29	129	91	95	155	501
Less int'l bond market inflows	(D) =10% *A	1	14	64	46	47	77	250
Investment gap	(E)= A-B-C-D	**3**	**43**	**193**	**137**	**142**	**232**	751
Annualised finance requirements	(F) =E/10	0	4	19	14	14	23	
Investment support (Finance sought to cover the hedging costs at 4%)	(G)=4% *(E)	**0**	**2**	**8**	**5**	**6**	**9**	

Source: CEEW-CEF analysis

Note:

a. In the absence of any data pertaining to the share of investments in green H_2 and H_2 production by electrolysis, we assume the banking and NBFC share in investment needs to be 40 per cent. We also assume that domestic bond and international bond market sources will be able to meet 20 per cent and 10 per cent of the investment needs for H_2-related investments.

b. Amounts in constant 2020 USD billion

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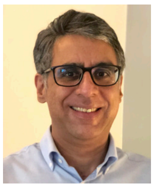

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