Commercializing large-scale hydrogen hubs through public-private partnerships

Regional Hydrogen Hubs: A $5B National Roadmap for 2030

Pathway to commercially-viable, replicable Green Hydrogen Hubs in India

IH2A
INDIA HYDROGEN ALLIANCE

FTI CONSULTING™

Sept 2023

IH2A PROPOSED PLAN TO GOVT OF INDIA (JUNE 2022)

National 25/25 Green H2 Development Plan – 25 H2 project clusters by 2025

First-Generation National Green H2 Projects to accelerate commercialisation, learning rates, induce demand at critical scale

Scalable, Co-located National Green H2 Projects using RE-Electrolysis, Gasification across RE-rich coastal states ('India's Hydrogen Valleys')

18 GH2 Project Clusters (w/RE-Electrolysis)
Industrial, Heavy-Duty Transport Offtake, each potentially scalable to GW capacity

7 Green H2 Bharat Cities - Waste-to-H2 Municipal Projects (with Gasification)
Local Industrial, Municipal Transport Fleets

25 National Large-Scale Projects by 2025
150 MW Installed Electrolyser Capacity
Green H2 Use in Industrial, Heavy Duty Transport
Future Coastal Shipping, Land Transport (Liquid, Gas)

Five Key Enablers

National Green H2 Dev Corp (NHDC) & Public-Private Taskforce

State Green H2 Plans, Nodal Office

Project Dev SPVs, Consortia

Public Funding/ Infra, National Innovation Status

National Testing/ Certification, Standards, Skilling

CENTRAL GOVT NGHM	Being Evaluated	State Partnerships	Two H2 Hubs	USD 2 bn+ allocated	Technical Advisory Group proposed

IH2A
INDIA HYDROGEN ALLIANCE

First-Generation National Projects (Phase I – 2023-2025)

26K+ tonnes Green H2 Induced Demand pa. with USD 360 mn Public Spend over 3 years, 2.6 Mmt CO2 reduction in a decade

PHASE I	150 MW Green H2 production capacity by 2025; 26,000 tonnes pa. industrial offtake; scalable	PHASE II	500 MW+ Green H2 production capacity

GUJARAT H2 HUB/ PROJECTS & STATE PLAN

- **Green H2 & Ammonia Hub - Bharuch-Ankleshwar-Dahej Chemical / Industrial Cluster -** GIDC-GNCF led SPV, proximity to Cement, Fertilizers & Steel clusters
- *Other Clusters – Vadodara, Ahmedabad-Gandinagar-Dholera, Surat-Navsari-Hazira)*

MAHARASHTRA H2 HUB/ PROJECTS & STATE PLAN

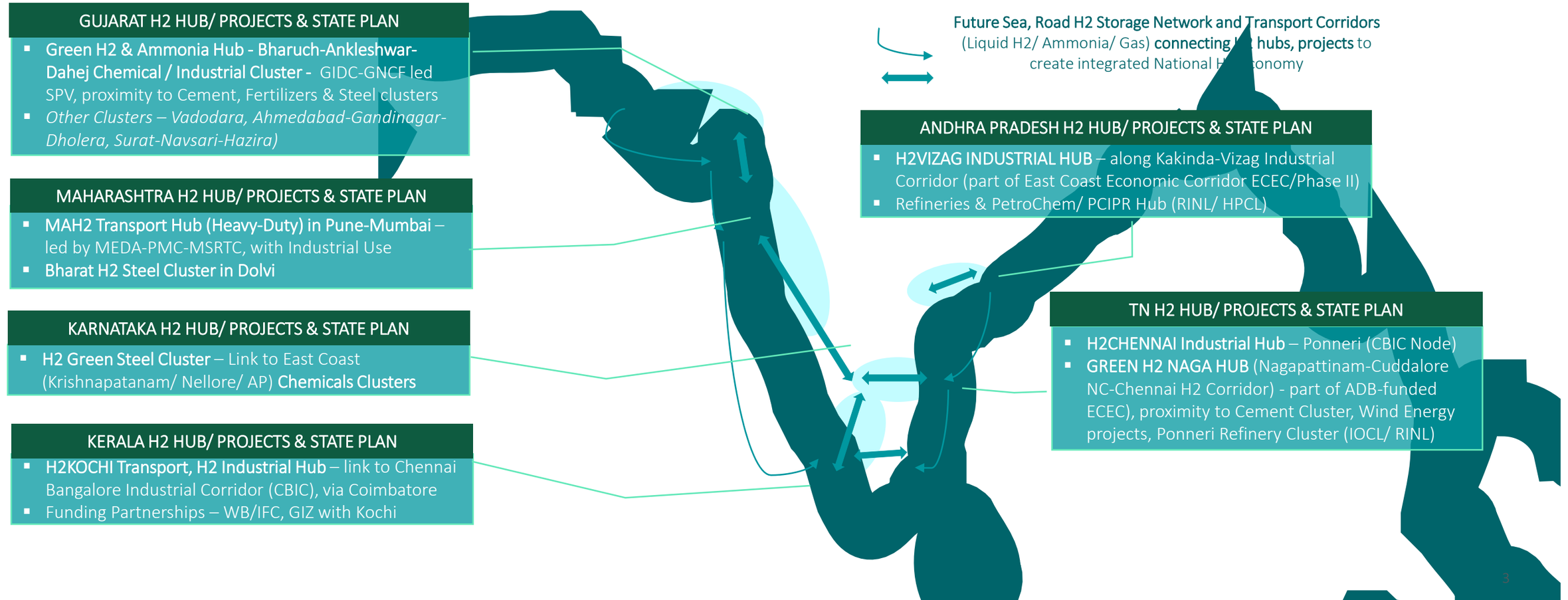
- **MAH2 Transport Hub (Heavy-Duty) in Pune-Mumbai** – led by MEDA-PMC-MSRTC, with Industrial Use
- **Bharat H2 Steel Cluster in Dolvi**

KARNATAKA H2 HUB/ PROJECTS & STATE PLAN

- **H2 Green Steel Cluster** – Link to East Coast (Krishnapatanam/ Nellore/ AP) **Chemicals Clusters**

KERALA H2 HUB/ PROJECTS & STATE PLAN

- **H2KOCHI Transport, H2 Industrial Hub** – link to Chennai Bangalore Industrial Corridor (CBIC), via Coimbatore
- Funding Partnerships – WB/IFC, GIZ with Kochi



Future Sea, Road H2 Storage Network and Transport Corridors (Liquid H2/ Ammonia/ Gas) **connecting H2 hubs, projects** to create integrated National H2 Economy

ANDHRA PRADESH H2 HUB/ PROJECTS & STATE PLAN

- **H2VIZAG INDUSTRIAL HUB** – along Kakinda-Vizag Industrial Corridor (part of East Coast Economic Corridor ECEC/Phase II)
- Refineries & PetroChem/ PCIPR Hub (RINL/ HPCL)

TN H2 HUB/ PROJECTS & STATE PLAN

- **H2CHENNAI Industrial Hub** – Ponneri (CBIC Node)
- **GREEN H2 NAGA HUB** (Nagapattinam-Cuddalore NC-Chennai H2 Corridor) - part of ADB-funded ECEC), proximity to Cement Cluster, Wind Energy projects, Ponneri Refinery Cluster (IOCL/ RINL)

Building commercially-viable Green Hydrogen Hubs in India

Public-private partnership to accelerate the hydrogen economy, build USD 5 bn in enterprise value alone

1 Hydrogen Hub Production, Storage and Evacuation Infrastructure Development will require govt participation (as equity partner), inducing demand by enabling guaranteed offtake for early defined volume, and incentives for infra development over first 7 years (2024-30).

2 Large-scale hubs will be commercially viable with offtake prices between USD 6-4.25 between 2024-30, for delivered green hydrogen prices i.e. at demand or offtake point, as per preliminary estimates. A financially viable hub design in Green Kochi Hydrogen Hub (GKH2) indicates:

a) GKH2 Hub could be potentially worth in excess of USD 1 bn on enterprise value and could be a potentially listed as India's 1st standalone Hydrogen Company
b) If USD 1 bn GKH2 Hub model is successfully replicated across five hub locations, their combined enterprise value alone will be worth in excess of USD 5 bn.
c) Without commercially viable hydrogen hubs, India's green hydrogen mission's 2030 ambitions will be at risk.

3 Potential listing of a USD 5 bn National Hydrogen Development Corporation, acting as holding company for at least five national hydrogen hubs, by 2030 – with government playing a lead market development role and driving hydrogen commercialization.

INDIA'S FIRST USD 1 BN HYDROGEN DEVELOPMENT CORPORATION, VIA PUBLIC-PRIVATE PARTNERSHIP

Green Kochi Hydrogen Hub (GKH2) – designing a financially viable H2 infra hub

IH2A INDIA HYDROGEN ALLIANCE

SUPPLIERS → Captive RPO Contract → **USD 200 mn KGH2 PRODUCTION – STORAGE – EVACUATION INFRA SPV** (recap in 2031)
50% Govt – Govt of Kerala (ANERT, KSRSTC), Govt of India (BPCL, FACT), with off-takers
50% Private – 4-5 Entities + RE Supplier Co., incl. off-takers
→ Take-or-Pay Guaranteed Offtake/ HPO Contracts → **OFFTAKERS**

RE INPUT COST, est.
USD 3-2.5 (2024-30), USD 2.2-1.6 (2031-43)

MULTILATERAL FUNDING CONSORTIA
Fund USD 468 mn CAPEX @ 6% pa, for 150 MW EC + BoP + Storage + Evacuation/ Fuelling Infra

GREEN H2 PRICE (Delivered), for 21000 MT pa.
USD 6-5.5 (2024-27), USD 5-4.25 (2028-30), USD 4-1.5 (2031-43)/Market Price

C.

RE SUPPLIER 480 MW
CAPITVE RPO

WATER INPUT
KOCHI MUNICIPALITY

A1, A2, A3

Compressed GH2
GH2 (Feedstock)

in-situ

H2, NH3 PRODUCTION 60 TPD
ADJACENT BPCL KOCHI REFINERY

STORAGE

EVACUATION / DISPENSING

LH2/ LNH3 Storage & Liquification
Liquid H2 / NH3 Storage

16 LH2, LNH3 Trailers & 16 HRS
BPCL-KSRTC Depot (HRS)

Future LH2/ LNH3 Corridor Shipments (Coastal Shipping), Kochi Terminals

COASTAL H2/NH3 SHIPMENTS

Kochi Refinery
Feedstock

Future GH2 Kochi-Mangalore pipeline

Mangalore Refinery Offtake

B3. 30 TPD
REFINERY PLANT

B1. 10 TPD
FERTILIZER PLANT

B2. 20 TPD
HICE TRANSPORT FLEETS

FACT Fertilizer
Feedstock

KSRSTC HICE Fleet
Fuel (Buses, Boats)

Private HICE Fleet
Fuel (Trucks)

FINANCIALLY VIABLE
Guaranteed offtake, at defined price; as per existing RE projects

CENTRAL, STATE GOVT INCENTIVES TO GKH2 HUB INFRA (excl SPV capitalisation)
USD 210 mn for Hub CAPEX/Infra + USD 163 mn in price incentives till 2030

DEMAND-SIDE INCENTIVES
Shadow Carbon Price (USD 60/MTCO2), Contracts for Difference (CfD) for Hubs

SPV (PART A1+A2+A3) is an enterprise-vehicle/ SPV that absorbs most production, storage and evacuation-linked infrastructure CAPEX. It pools assets and risks; and is key execution/planning entity in Hub. It will be linked to strategic RE supply partner (PART C), three offtake groups (PART B) and Govt / Public Finance Support, all of whom should participate in equity of PART A SPV.

GKH2 Hub SPV^ – CAPEX, Production, Costs & Guaranteed Offtake

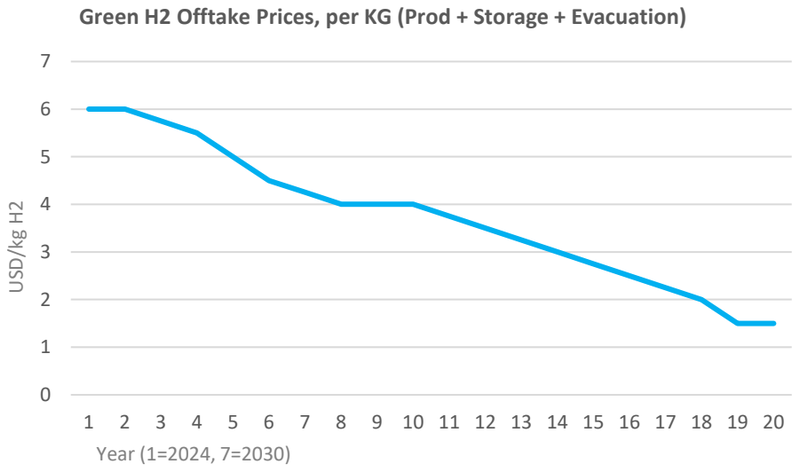
3-phase CAPEX build-out, with defined volume offtake across Transport, Fertilizer & Refinery (with offtake-linked incentives)

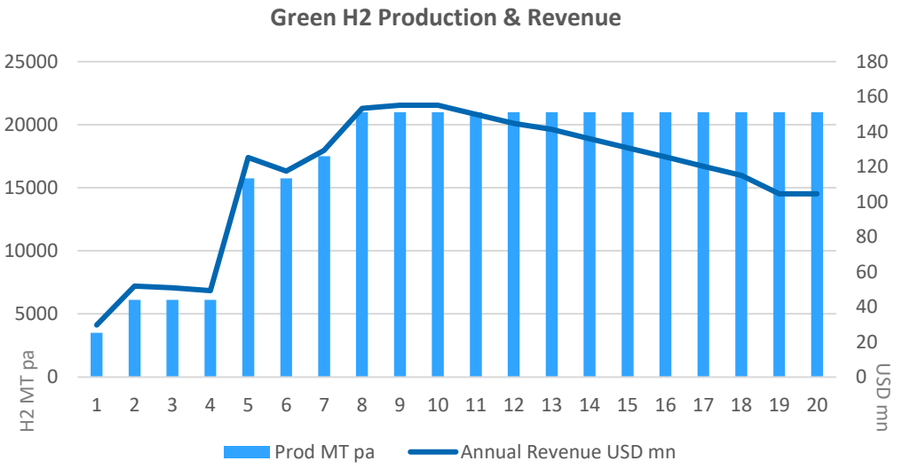
CAPEX PLAN (MW/ US$ mn)	2024-27	2028-30	2031-32
EC Capacity Addition (in MW)	50	50	50
A1. H2+NH3 Production Plant (EC+BoP)	185	132	127
A2. Storage & Liquification Facility	16		
A3. Transport Infra – 16 Trailers, 16 HRS		8	
TOTAL, US$ mn	**201**	**140**	**127**

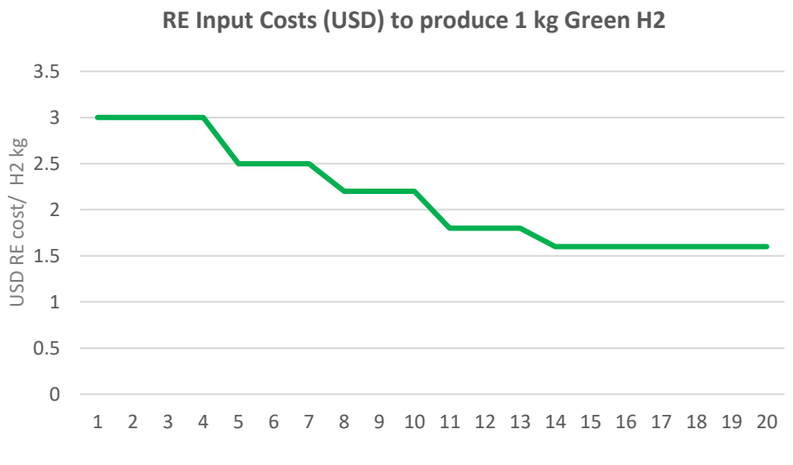
GREEN H2 OFFTAKE, MT pa (with volume-defined price support)	2024-27	2028-30	2031-43
B1. LH2 in Transport Use (USD 2-1.5/kg till 2027, USD 1-0.25/kg till 2030)	3500	3500	7000
B2. Green Ammonia Use* (USD 4-3.5/kg till 2027)	2625	3500	3500
B3. Green H2 for Refinery Use* (USD 3-2.25 from 2028-2030)	-	8750	10500
TOTAL, MT pa	**6125**	**15750**	**21000**

*Contracts for Difference (CfD), Shadow Carbon Price offset for B1 Transport Offtake above USD 4/kg to pay for storage and refuelling infra; and for B2 and B3 Industrial Offtake above USD 2/kg.)

Offtake volume-based incentives in initial period (2024-2030/ Yr 7) to cover costs above USD 2/kg (industrial), USD 4/kg (transport) offtake important for financial viability, induce early offtake







^based on economic model built by FTI Energy Policy & Economics Group, for IH2A

GKH2 Hub SPV^ – Financing Plan & Targeted Outcomes

Financially viable project with targeted 18% IRR, public benefits exceeding incentives

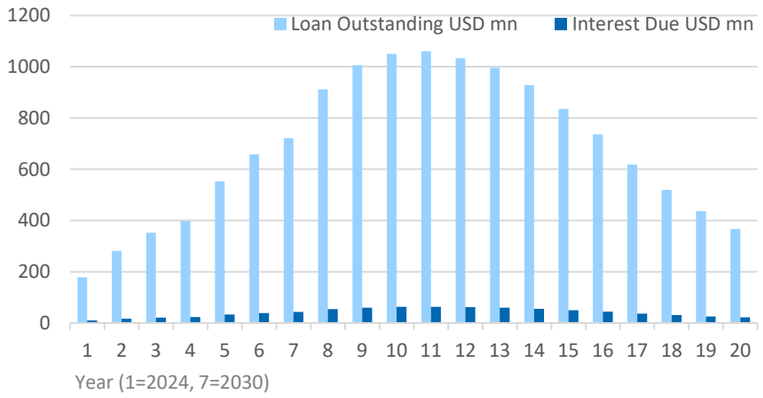
ASSUMPTIONS	TILL 2030	POST 2030
Concessional Credit Interest Rate, %	6	6
Annual Outstanding Principal Repayment, %	10	10
CAPEX Depreciation Rate (over 15 yrs), %	7.5	7.5
Promoter Equity (50:50 Public-Private), USD mn	200	400
Tax Rate, %, wef 2028	20	20
Dividend Date, %, wef 2028	3	3
Govt Incentives for CAPEX, Infra Funding, USD mn.	210	100
Volume-based H2 offtake incentives – Transport, USD mn*	33	-
Volume-based H2 offtake incentives – Fertilizer, USD mn*	73	45.5 (next 10 yrs)
Volume-based H2 offtake incentives – Refinery, USD mn*	71.8	136.6 (next 10 yrs)

*offtake incentives to be funded separately, outside SPV structure, directly by govt

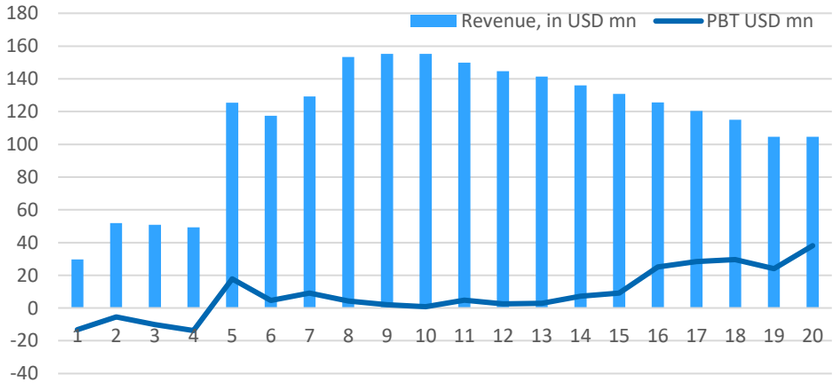
TARGET FINANCIAL OUTCOMES	TILL 2030	POST 2030
Project IRR, %	18	18
Debt-Equity Ratio (Range)	0.9-3.6	2.3-0.9
Net Profit Margin	6-11%	4-18%
Return on Equity	5%	10%

TARGET OPERATIONAL OUTCOMES (ESTIMATES)	METRIC
CO2 Reduction, MT pa	19,000
New and Re-Skilled Jobs	10,000

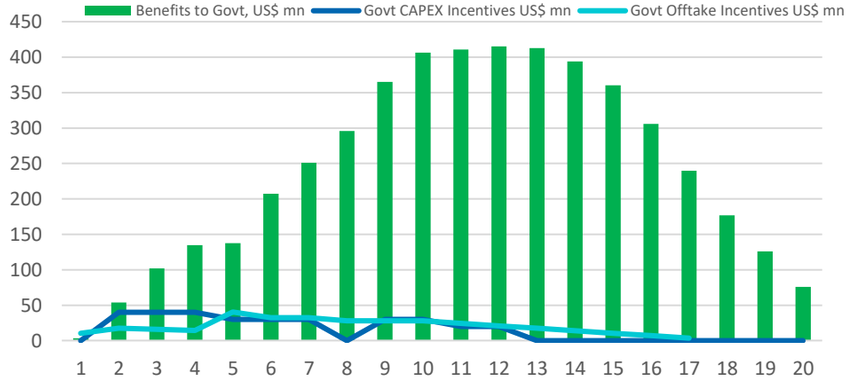
Loan Outstanding & Interest Payment Schedule



Revenue & Profits Before Taxes (PBT)



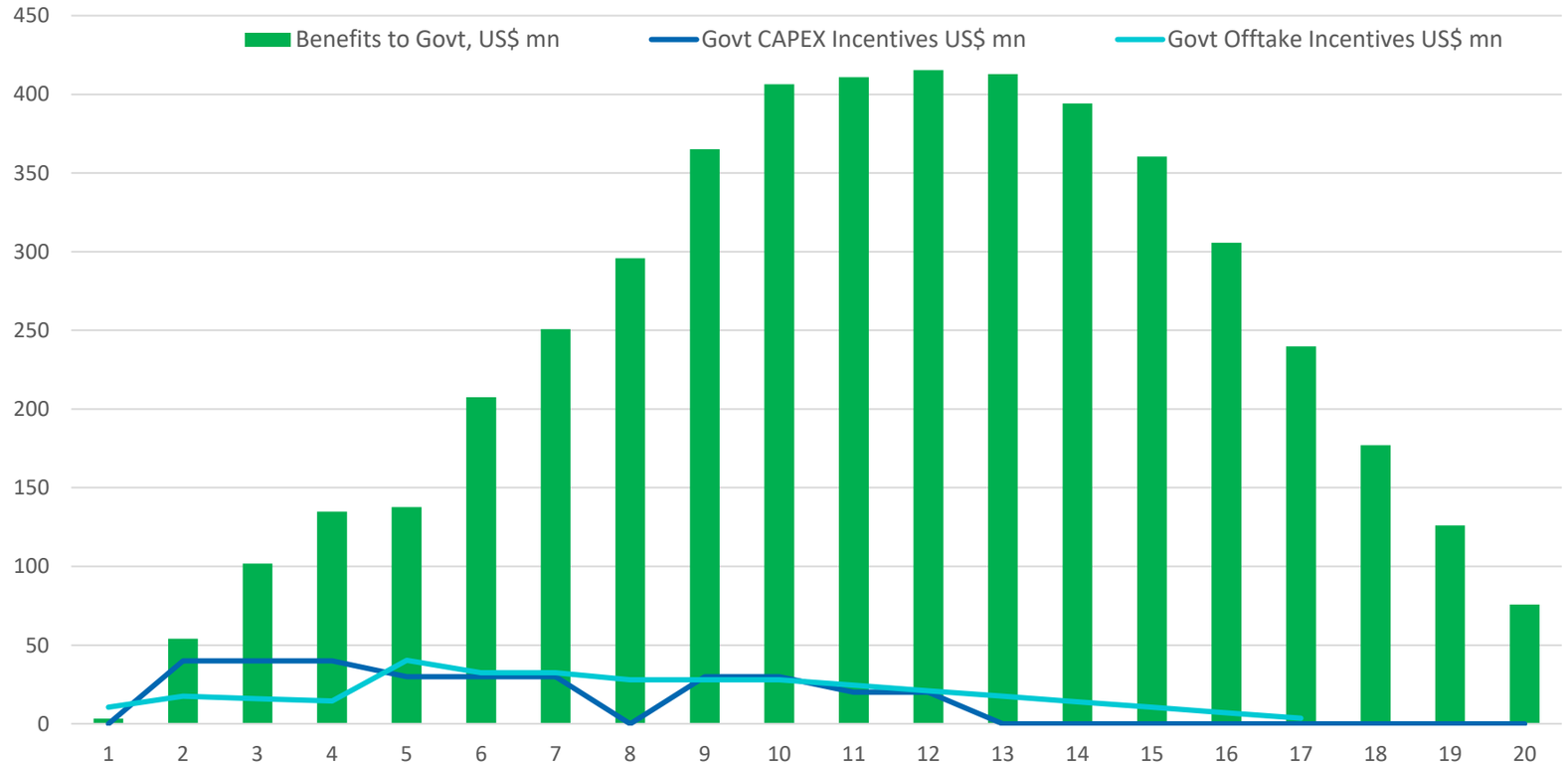
Benefits to Govt Vs. Incentives



^incl. 50% equity value, 100% taxes, 50% Dividends, Carbon Credit for CO2 reduction

^based on economic model built by FTI Energy Policy & Economics Group, for IH2A

Benefits to Govt^ Vs. Incentives (CAPEX + Offtake Support) for Green H2 Hub*



^incl. 50% equity value, 100% taxes, 50% Dividends, Carbon Credit for CO_2 reduction

^based on economic model built by FTI Energy Policy & Economics Group, for IH2A
**based on Green Kochi Hydrogen Hub SPV model (reference large-scale project/hub structure)*

Priority States for National Green Hydrogen Hubs

Based on IH2A's proposal to State Governments, as public-private partnerships*

KERALA	GUJARAT	MAHARASHTRA	TAMIL NADU	ANDHRA PRADESH	KARNATAKA
Green Kochi Hydrogen Hub	Green Hazira Ammonia and Hydrogen Hub	Green Raigad Hydrogen Hub	Green TN Ammonia & Hydrogen Hub	Green Vizag Ammonia & Hydrogen Hub	Green Karnataka Hydrogen Hubs

**IH2A has submitted hub proposals to each of these state governments*

Priority Actions to accelerate H2 Commercialization during India G20 Presidentship

Sr. No.	KEY ACTIONS
1	**Green Hydrogen Offtake Price Incentives for Large-Scale Green Hydrogen Hubs** (>100 MW Electrolyser Capacity), to induce green hydrogen demand and support project development
2.	**National Green Hydrogen Demand Aggregation from Public-Sector side and development of Hydrogen Purchase Obligations (HPOs)** – for refinery, fertilizer, steel, chemicals and cement plants
3.	**Five National Large-Scale Green Hydrogen Hubs, with public-participation, as Large Infrastructure Projects of National Importance, and initiate techno-economic studies for the hubs** – and launch at least one National Green Hydrogen Hub during India's G20 Presidentship (at G20 Summit before September 2023)
4.	**Market Study of Hydrogen Economy and Supply Chain, to evaluate potential value of all hydrogen related equipment, infrastructure and machinery required** (including electrolysers, Balance of Plant equipment, compressors, pipelines, storage equipment/ tanks, hydrogen refuelling stations and evacuation infrastructure), together with the industry

Thank you

IH2A SECRETARIAT:
Amrit Singh Deo, Prasanto Roy, Rakesh Aulaya, Sarang Dublish, Pragya Gupta, Kerban Rajdeo, Devanshu Jain
sec@ih2a.com