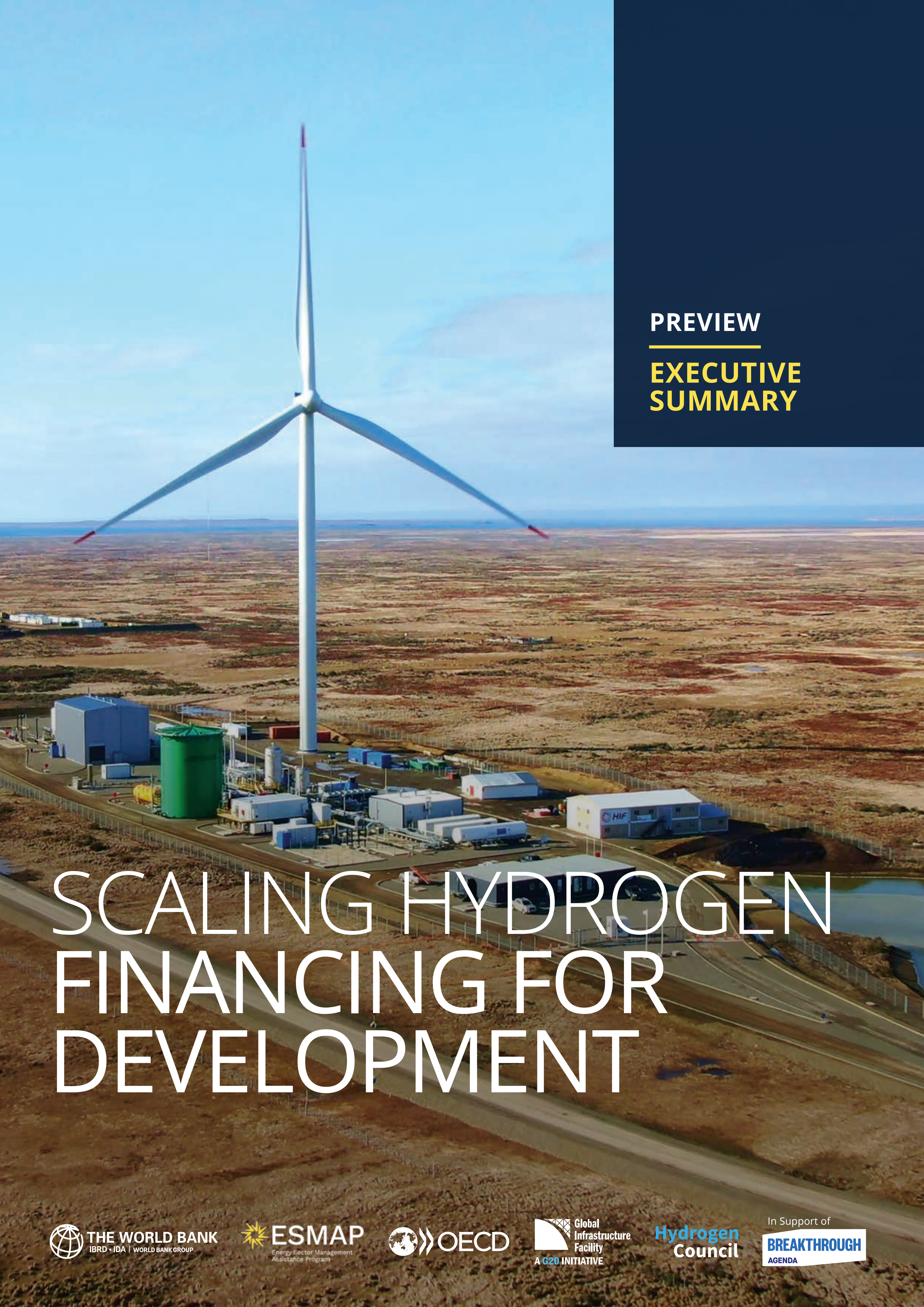

PREVIEW

EXECUTIVE SUMMARY

SCALING HYDROGEN FINANCING FOR DEVELOPMENT

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

ESMAP
Energy Sector Management Assistance Program

OECD

Global Infrastructure Facility
A G20 INITIATIVE

Hydrogen Council

In Support of
BREAKTHROUGH AGENDA

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ABOUT ESMAP

The Energy Sector Management Assistance Program (ESMAP) is a partnership between the World Bank and over 20 partners to help low- and middle-income countries reduce poverty and boost growth through sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank's country financing and policy dialogue in the energy sector. Through the World Bank Group (WBG), ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable, and modern energy for all. It helps to shape WBG strategies and programs to achieve the WBG Climate Change Action Plan targets. Learn more at: https://esmap.org

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Report Contents

Key Findings

- **STATUS.** Clean hydrogen—hydrogen[1] produced from renewable energy, and fossil fuel with safe and responsible carbon capture and storage—can play an important role in the global transition from polluting fuels to low- or no-carbon energy, helping to achieve universal access to affordable and reliable energy by 2030 (Sustainable Development Goal 7). Hydrogen is an energy carrier that can be used to store, move, and deliver energy and, if produced from clean sources, is particularly promising for use in hard-to-decarbonize sectors such as steel production, long-haul transport, and others. The challenge today, however, is that current global production of clean hydrogen is limited, representing less than 2 percent of total hydrogen production. While clean hydrogen trade can change the geopolitics and security aspects of energy, this is a very capital-intensive industry. Therefore, to increase the number of clean hydrogen projects globally, they need to be commercially attractive. To achieve this, a focus on financing and risk mitigation is needed to create viable investment opportunities. In response to strong country interest, $1.65 billion in World Bank funding has been approved for green/renewable hydrogen loans so far in 2023, with more to come. Presently, 39 percent of all global clean hydrogen projects under development are in emerging markets and developing countries (EMDCs). However, so far only six large renewable hydrogen projects (>100 MW capacity) in EMDCs have reached the final investment decision (FID) stage.
- **OUTLOOK.** To meet global climate goals, emerging markets and developing countries must play a key role and supply half of global production, equivalent to 20 Mt/year by 2030. That is equivalent to 100 NEOM projects, the largest hydrogen project under construction in Saudi Arabia, projected to come onstream in 2026. Production of ammonia, methanol, and steel are among the main hydrogen applications. Modeling studies suggest that 25 to 31 percent of hydrogen production will be traded internationally by 2050. However, funding needs are significant to realize this vision. EMDCs require around $ 100 billion per year in investments between now and 2030 – a huge sum that makes private sector participation critical.
- **ACTION PLAN.** A four-point action plan to accelerate clean hydrogen deployment in EMDCs is suggested. It centers on a series of renewable hydrogen lighthouse projects designed to increase investor confidence. We propose a 10 GW initiative, aiming to develop projects (between 100 MW and 1 GW in size) across different nations and different settings to demonstrate viability for all stakeholders, reduce financing cost premiums, and create scalable solutions. Given its urgency, the effort should begin with promising projects currently in the global pipeline, keeping in mind aspects such as

[1] Hydrogen is the most abundant element in the universe and occurs naturally on earth in compound form with other elements in liquids, gases, or solids. Hydrogen combined with oxygen is water (H_2O).

technology and application diversity, replicability, and cost effectiveness. A general capacity-building and knowledge-sharing effort is also needed to bring governments up to speed on clean hydrogen opportunities and challenges.

- **HYDROGEN COST.** The information presently available on costs and prices for clean hydrogen is insufficient to guide policymaking and investment decisions. More transparent price information should be created. For renewable hydrogen (hydrogen produced from renewable power such as wind and solar), today's lowest production cost is $3/kg for best-in-class projects; that cost can rise to more than $10/kg under less favorable conditions. In most locations, these costs are well above those for conventional hydrogen (generated from fossil fuel energy without carbon capture) and blue hydrogen (generated from fossil fuel energy with carbon capture). The external financial support needed to close clean hydrogen's economic viability gap is estimated between $10 and $40 billion per year between now and 2030. This amount is known as the 'financing gap,' i.e., the gap between product value and production cost. The wide range stems from the uncertainties and challenges that surround the hydrogen industry's development.
- **DE-RISKING.** Large clean hydrogen projects in EMDCs face high financing costs derived from actual and perceived risks, deterring investors to enter this nascent industry. Six key categories of risks have been identified, in order of priority: (1) offtake risks; (2) equally weighted political and regulatory risks; (3) infrastructure risks; (4) permitting risks; (5) technology risks; and (6) macroeconomic risks. The three categories of risks that were given a lower priority are: design, construction, and completion risks; operational and maintenance risks; and supply risks. Implementing cost-effective and efficient de-risking mechanisms could substantially decrease the weighted average cost of capital, making projects economically viable and thus accelerating deployment and reducing the financing gap. Only through application of dedicated risk mitigation mechanisms can large-scale clean hydrogen projects in EMDCs achieve financial viability. It is critical that EMDC governments choose reputable partners for project development.
- **FIRST MOVERS.** Policies promoting clean hydrogen in a few first-mover countries can spur development elsewhere and begin to decrease costs. Governments' willingness to share and absorb risks is critical to accelerating investment. Benefits await the competitive EMDCs that choose to participate in this process as first movers. Clean hydrogen production in EMDCs would strengthen the international value chain, yielding substantial socioeconomic development benefits and increasing countries' energy security. Multilateral development banks (MDBs) and development finance institutions have a strategic role to play in supporting EMDCs willing to become first movers. They can support governments to attract private sector investment by improving enabling conditions, de-risking investments, reducing costs, and promoting adequate financing instruments. Moreover, they can support countries in defining policy frameworks that catalyze local socioeconomic benefits and climate mitigation to align with national development agendas. Better coordination among participating international institutions will reduce transaction costs and speed up approvals such as through the harmonization of approval and due diligence procedures.

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Executive Summary

Clean Hydrogen Will Be a Key Part of the Future Global Energy System

Clean hydrogen[2] is widely seen as a key component of the global energy transition, notably for its potential to decarbonize hard-to-abate sectors, such as heavy industry (cement, steel, and chemicals), and heavy-duty transport (trucking, shipping, and aviation). A global hydrogen economy will change the geopolitics of energy and could become an engine for sustainable economic growth in emerging markets and developing countries (EMDCs). Several EMDCs are well positioned to become first movers in the development of this new value chain, both for domestic consumption and for export. Many countries have already issued strategies and roadmaps to operationalize their ambitions. As a next step, well-aligned policies adapted to those strategies are necessary to leverage private financing and mitigate the risks of first movers' investments.

The cost of clean hydrogen is a major sticking point in its widespread adoption and deployment. While most attention to date has focused on innovation strategies to lower technology costs, financing costs have received less attention. This report analyzes the importance of the cost of financing, identifies the project risks that drive up such financing cost, and proposes risk-mitigation measures. The report describes how governments can support deployment by reducing the costs of both technology and financing.

Successful projects in the coming years will typically require a combination of strong sponsors, robust regulation, long-term offtake arrangements, and financial support. Governments have a key role to play in this early phase. Hydrogen policies on both the supply side and the demand side must be well integrated for the greatest effect and efficiency. A careful selection of early hydrogen projects can reduce the need for government financing.

Clean Hydrogen Production Must Grow Twenty-Fold by 2030

Realizing hydrogen's potential means first replacing today's fossil fuel-based hydrogen production with a cleaner variety. To meet the 2050 climate goals, today's levels of clean hydrogen production must increase 20-fold (~40 Mt) through 2030. Today, less than

[2] "Clean hydrogen" includes hydrogen produced from fossil fuels coupled with carbon dioxide capture and storage (combustion based) or carbon storage (pyrolysis based). These are also known as low carbon hydrogen or "blue hydrogen." Hydrogen produced from water electrolysis using renewable electricity or from biomass is known as renewable hydrogen or "green hydrogen." "Conventional hydrogen" refers to fossil fuel-based production without carbon dioxide capture and storage.

2 million tonne (Mt) of clean hydrogen is produced each year. Current projections suggest that of the 40 Mt of clean hydrogen production needed by 2030, an estimated two-thirds would come from renewables while the rest would be of the low carbon variety.

Clean hydrogen today is more expensive than conventional hydrogen produced from fossil fuels. This cost gap is the main factor why clean hydrogen projects are often viewed as unviable. Rule of thumb cost estimates for best-in-class projects with optimistic assumptions in favorable locations is $1/kilogram (kg) to produce conventional hydrogen, $2/kg for low carbon hydrogen, and $3/kg for renewable (green) hydrogen, respectively, though clean hydrogen (hydrogen from fossil fuels with carbon capture/storage) can already compete under certain favorable circumstances. Costs vary widely, however, especially for renewable hydrogen. Some EMDCs can be among the lowest-cost producers of clean hydrogen worldwide owing to their favorable renewables resource endowment. Moreover, their resource potential is very significant. This is a key reason why they should be part of early hydrogen development efforts. Existing country cost rankings from literature and modelling studies are of limited value as changing project specifics, market dynamics, and enabling environments can affect cost significantly. There is a need to develop more accurate hydrogen cost and pricing information for today and the coming years.

When hydrogen is traded internationally, the transportation cost can be as great as the production cost. That is a major reason why there is no international hydrogen commodity market. No significant shipping capacity for liquid hydrogen exists at present. Instead, hydrogen is being shipped in the form of ammonia, a globally traded commodity. Other synthetic hydrocarbon shipping options are being explored, and costs are projected to fall in the coming years. Pipeline transportation can be significantly cheaper than shipping for distances up to several thousand kilometers.

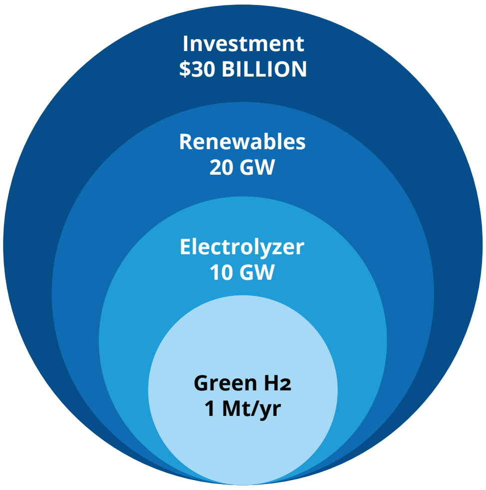
EMDCs Will Need $100 Billion in Investment Annually for Projected Growth in Clean Hydrogen

Existing hydrogen import policies, national plans, project pipelines, and model analyses indicate that 25 to 50 percent of clean hydrogen production is likely to come from EMDCs.[3] The upper end of the range was used for this analysis (20 Mt of clean hydrogen production from EMDCs in 2030). These projections are uncertain; policy and regulatory frameworks will have a profound impact on choices of production locations and volumes for first movers.

[3] China, the world's largest hydrogen market, set up two large renewable hydrogen projects in 2023. The country is aiming for 5 Mt of renewable hydrogen by 2030, 20–25% of total EMDC production. However, China's clean hydrogen supply ambitions need further elaboration, and no massive exports are foreseen. Given the magnitude and particular characteristics of China's hydrogen policies (the country has ambitious hydrogen vehicle plans, notably at the subnational level), the country is treated separately from other EMDCs in this analysis.

FIGURE ES.1

Key Characteristics of Renewable Hydrogen Production by Component



Source: Authors' analysis.

Scenario studies and the project pipeline suggest that EMDCs have the potential to attract clean hydrogen investments in the order of $100 billion per year between now and 2030, more than a ten-fold increase from present levels. Renewable hydrogen, which is more capital intensive than other forms, will account for 80 percent of the clean hydrogen production investment and financing needs.[4]

The external financial support needed to realize these investments in EMDCs and to close the economic viability gap is estimated between $10 and $40 billion per year between now and 2030. This amount is known as the "financing gap."[5] These amounts stand out in light of the fact that development financing worldwide presently totals just $200 billion per year. A number of strategies can be deployed to mobilize these investments, however, individual projects costing billions or tens of billions of dollars can pose particular challenges.

It will be essential to mobilize private sector financing for clean hydrogen to minimize dependence on scarce international and public financial support. Initiatives such as the World Bank's recently launched Private Sector Investment Lab[6], the blended finance principles

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[4] All investment and financing numbers in this publication include the renewable power component, which is not included in some other sources.

[5] The "financing gap" refers to the difference between the level of financing needed and the level that is commercially justifiable. The gap is calculated based on the disparity between product value and production cost. The gap is equal to 10-40% of total financing needs.

[6] The Private Sector Investment Lab aims to address obstacles to private sector investment in emerging markets, with a focus on renewable energy and climate goals. It brings together private finance leaders and experts to develop solutions for mobilizing private capital to combat climate change and reduce poverty in these regions. The MDBs' blended finance approach is described here.

embraced by multilateral development banks (MDBs), and the Blended Finance Principles of the Organisation for Economic Co-operation and Development[7], as well as public-private partnerships to mobilize more private finance will be crucial to get initial projects off the ground.

The EMDC Project Pipeline is Full of Projects Stuck in Early Stages

Around 39 percent of today's project pipeline is in EMDCs, with important activity concentrated in the Middle East, Latin America, India and China, followed by sub-Saharan Africa and other Asia. But translating high-quality renewable endowments into hydrogen production investments remains a challenge.

The main challenge for EMDCs is to push projects toward the front-end engineering design (FEED) stage. There is a relatively low representation of EMDCs (7 percent) at that stage, compared with developed countries (93 percent). To date, very few large projects have entered the final investment decision (FID) stage worldwide. The value of clean hydrogen projects in EMDCs that have reached the FID stage is less than $20 billion.

The share of investments in EMDCs is 44 percent, including China's 18 percent share. However, the 44 percent figure is largely dependent on a few projects, such as NEOM in Saudi Arabia.

Because risk-mitigation measures are not far advanced, cost of capital is high and it is challenging to find offtake; many announced projects are stuck in early stages of development, struggling to complete the FEED studies.

Low-Cost Financing Must Be Combined with Lower Investment Costs

Projections of falling production costs for renewable hydrogen depend critically on two factors: lower installed costs of electrolyzer systems[8] and competitive costs of renewable power. From the export perspective, transportation costs are also critical.

The production costs of clean and conventional hydrogen are expected to converge around 2030, provided greenhouse gas emissions are priced properly and the unit investment cost for renewable hydrogen maintains its downward trend. The convergence also depends on

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[7] The OECD's Blended Finance Principles are a policy tool for donor governments, development cooperation agencies, philanthropies, and other stakeholders to design and implement effective and transparent blended finance programs. More details are available from OECD's Blended Finance Guidance and Principles.

[8] An electrolyzer system consists of an electrolyzer stack and balance of plant (BOP).

whether the cost of capital declines as technology matures, as project developers gain experience, and as financiers become more comfortable with clean hydrogen projects. These factors can be mutually reinforcing.

To achieve 2030 convergence, a virtuous circle is needed in which governments support first movers' projects by financing the technology, education, and scale needed to accelerate deployment and create a viable market.

The near-term prospects for reductions in electrolyzer cost remain uncertain. Today's costs vary significantly by market, based on variations in costs in China, Europe, India, and the United States. The same uncertainty can be observed for the cost of electricity used to produce renewable hydrogen. The costs incurred by renewable electricity and the hours of electrolyzer operation will depend on the carbon standard that hydrogen production must meet. Initially, the interpretation of "low carbon" should be flexible enough to yield affordable hydrogen; the standard can be tightened in later years as the costs of renewable electricity and electrolyzers fall and as demand rises. But internationally traded hydrogen and hydrogen derivatives may have to comply with global standards and regulations, which can be complex and challenging. Clean hydrogen definitions and standards that have recently been set in Europe and ongoing discussions in the United States can provide relevant insights. EMDCs will have to balance standard setting and continue their dialogue with offtakers.

The relative cost differential between clean and conventional hydrogen is less pronounced for hydrogen derivatives, such as ammonia, steel, methanol, and jet fuel. Moreover, the ease of transporting these commodities creates an opening for the deployment of clean hydrogen in EMDCs, and the increase in value added makes a strong development case. Bringing manufacturing companies, shipping, and airline companies, for example, on board can accelerate hydrogen production in early stages and enable EMDCs to internalize a larger share of the hydrogen value chain.

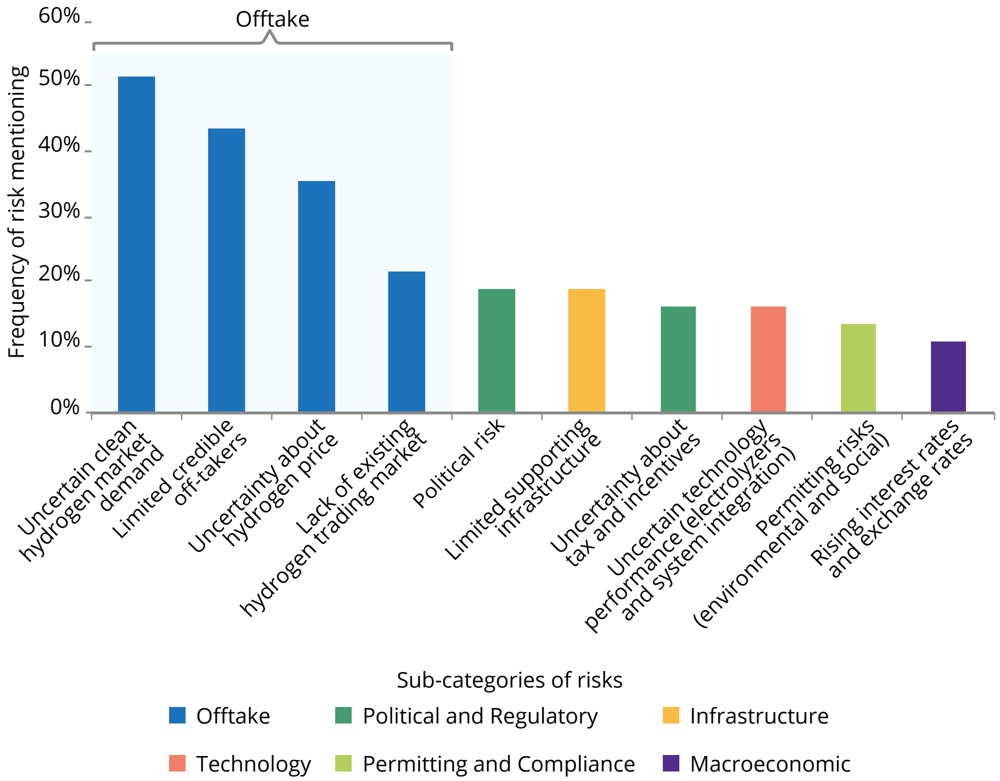
The cost of capital affects both the levelized cost of electricity and the levelized cost of hydrogen production. Rich resource endowments in EMDCs compensate somewhat—but not entirely—for the higher cost of capital in EMDCs. Even high-quality projects with reputable partners and accompanied by sovereign risk guarantees typically require double-digit cost of capital in EMDCs.

Managing Risk Well Will Accelerate Clean Hydrogen Deployment

Certain essential factors must be present before a clean hydrogen project can make it to the FID stage. Secure offtake in terms of volume, price, and project duration must be in place. Infrastructure to handle hydrogen, water, electricity, carbon dioxide, and hydrogen derivatives must also be in place when production begins. In addition, the product must be recognized as 'clean hydrogen' by established standards and certification systems.

FIGURE ES.2

Top 10 Identified Risks for Clean Hydrogen Projects in EMDCs



Source: Authors' analysis.

Post-FID risks center on construction overruns, offtake default, technology issues, political risk, and exchange risks, all of which affect the cost of capital and thus competitiveness. Once a project has reached the FID stage, targeted policies and risk-mitigation measures that reduce the cost of capital can decrease the cost disparity between conventional and clean hydrogen.

Some risks are country and actor dependent. These include the creditworthiness and credibility of the project sponsor; of the contractor responsible for engineering, contracting, and procurement; of the primary technology provider; and of the offtaker. All of these, of course, feature prominently in any risk assessment. Some aspects of political risk can be mitigated through well-established mechanisms offered by MDBs and development finance institutions (DFIs), such as political risk guarantees.

Clean hydrogen also carries perceived technology risks. Such risks can be mitigated by insurance or guarantees—for example, from export credit agencies in countries that produce electrolyzers. First-mover risk is also significant, where production costs are projected to fall in the coming years and product prices are likely to rise.

Governments Can Reduce Risk by Building Enabling Frameworks

Governments will play a vital role in the realization of clean hydrogen projects for the rest of this decade. They must create enabling policy frameworks and find solutions to close the financing gap for early projects.

Effective government policies can lessen the need for public financial support by creating the right enabling environment for investments, increasing pricing transparency, and reducing risk. Developed countries have already launched extensive mission-oriented strategies, with more than $100 billion in announced subsidies. EMDCs do not have the same financing power. However, careful selection of early hydrogen applications or an export-oriented strategy benefiting from partnerships with countries offering end-user incentives can substantially reduce financing needs.

Above all, governments must carefully choose the projects they wish to support in light of the projects' quality and likelihood of success. Development of hydrogen hubs that cluster suppliers and producers can reduce the size of individual projects and eliminate the need for extensive transportation infrastructure. Whereas export projects are likely to be very large, smaller scale opportunities exist for hydrogen use nationally, such as in refineries or for fertilizer production. National uses can complement exports.

Given the complexity of the hydrogen sector, governments should consider the appointment or establishment of an agency responsible for national hydrogen development. Adequate policies, regulation, and financial instruments will be essential to lower risks and to attract patient capital such as pension funds and sovereign wealth funds. In this context, refinancing projects upon completion is a way to lower the cost of investment capital and to unlock sources of funding with a higher risk appetite.

International Financial Institutions Can Accelerate Hydrogen Financing

MDBs and DFIs should strengthen their support for EMDCs that are taking steps to advance the energy transition on their territory—for example, through support for carbon pricing schemes and rapid rollout of renewable power generation.

Equally deserving of support are knowledge sharing, capacity building, and promotion of international cooperation. Here, examples include certification schemes' implementation, evolution of the market and pricing models, technical standards, and use of a single platform for channelling clean hydrogen development and climate funding and support. The World Bank's Hydrogen for Development Partnership, established at COP27 and managed by WB/ESMAP, is an example of such an effort.

For governments willing and able to become first movers, MDBs and DFIs can provide guarantees and deploy instruments to mitigate risks. This type of support includes technical assistance, development policy financing, infrastructure loans (e.g., for ports and pipelines), facilitation of offtake arrangements (including demand aggregation), and strengthened matchmaking between EMDC governments and international hydrogen initiatives.

MDBs and DFIs are well positioned to support so-called lighthouse production projects designed to encourage further investment in EMDCs. This type of support includes (1) prioritizing and enhancing the quality of project proposals; (2) supporting the initial stages of project development; (3) pooling international development funding for investments to lower financing costs and raise investor confidence; (4) participating in blended finance arrangements; (5) offering risk-mitigation instruments; and (6) monitoring and quantifying the climate change and development benefits of clean hydrogen projects.

To date, international support has concentrated on making EMDCs attractive sites for hydrogen production by improving the enabling environment for incoming investment (most of it export oriented) and ensuring the adequacy of essential infrastructure. But such supply-side assistance could be strengthened on the demand side by devising the right mix of tax incentives, regulations, and policies to entice local companies to decarbonize their activities through the use of clean hydrogen. Stimulating local demand would widen the path to clean hydrogen investment by lessening the logistics and infrastructure costs associated with export-oriented investment.

Better coordination among participating international institutions can reduce transaction costs and speed up deployment—for example, through harmonization of approval and due diligence procedures. MDBs should consider developing a joint strategy to ensure that limited amounts of concessional and development financing are used to their maximum effect, notably for projects in the early stages of development.

Advancing Support for Renewable Hydrogen Financing

COP28 will provide an opportunity to discuss support for renewable hydrogen lighthouse projects facilitated by MDBs and DFIs acting in concert. Lighthouse projects are necessary to accelerate the scaling up of the clean hydrogen market. Active government and financing institution support will be needed to operationalize a pilot program, tentatively with a 10-gigawatt (GW) electrolyzer capacity reaching the operational stage. Such a program can increase investor confidence in various EMDC settings, leading to lower financing costs and easier access to capital. Given its urgency, the effort should screen projects from the existing pipeline, using criteria such as diversity, replicability, project size, and cost effectiveness.

Scaling Up Clean Hydrogen Financing

Solutions for Development and Decarbonization

<2 Mt/yr. clean H_2 produced globally in 2022

<1 GW in global installed electrolyzer capacity for clean H_2 in 2022

Global clean H_2 production: **27 Mt** renewable and **13 Mt** low-carbon by 2030 **260 GW** in new solar and wind capacity needed

Global financing gap of **$500B** until 2030. Need for policy measures to close gap

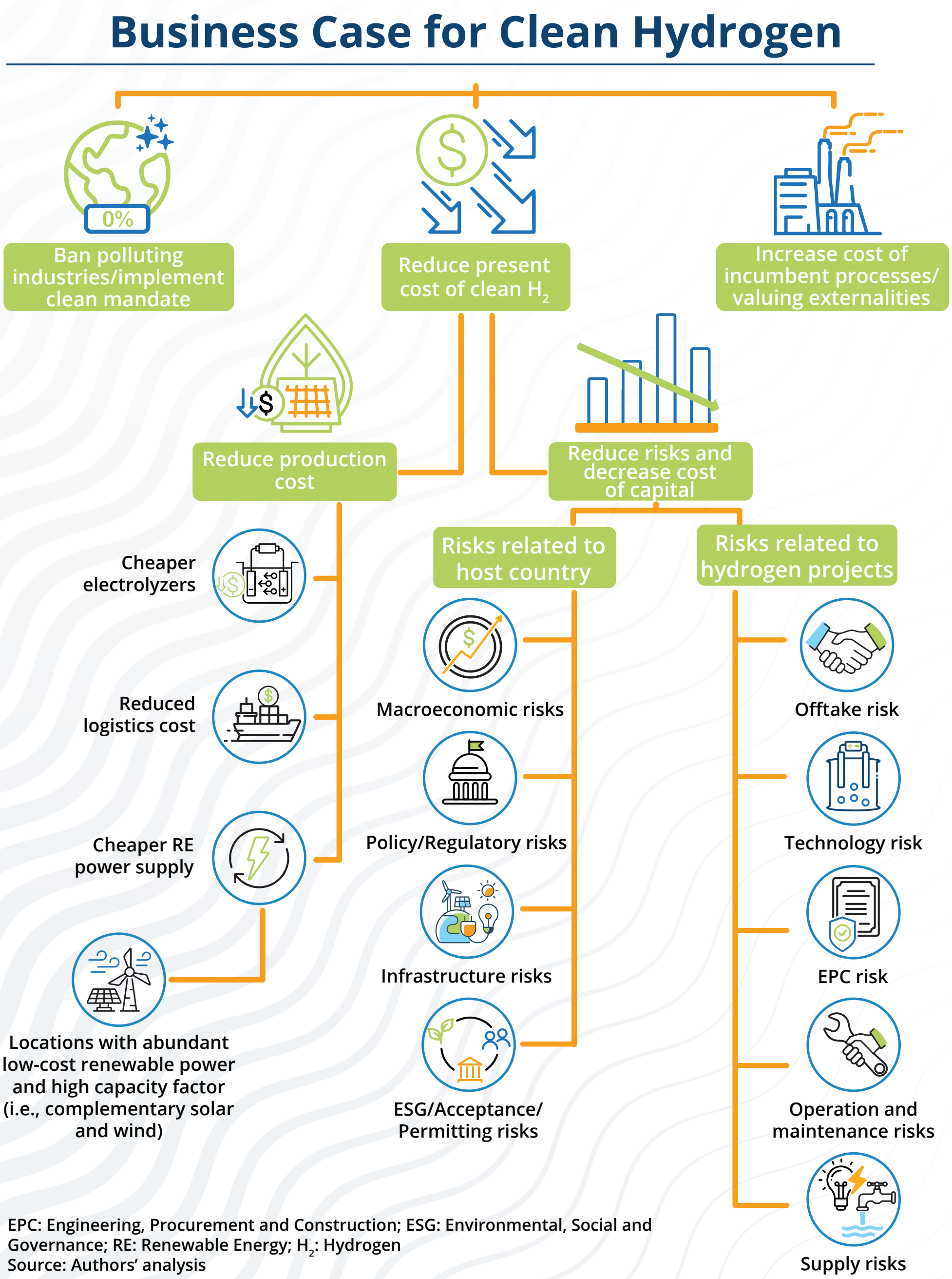
Renewable H_2 accounts for **80%** of production investment. Renewable power accounts for **60%** of EMDC investment needs

Global investment need until 2030: **$2T**
$1T (production);
$0.5T (transport infrastructure);
$0.5T (end-use sectors)

Global Clean H_2 demand (and production) **40 Mt** until 2030 with **20 Mt** expected in EMDCs

Total annual EMDC financing needs until 2030: **$100B/yr.**
Annual EMDC financing gap until 2030: **$10B-$40B/yr.**

EMDC: Emerging Markets and Developing Countries; $ refers to USD
Source: Authors' analysis



EPC: Engineering, Procurement and Construction; ESG: Environmental, Social and Governance; RE: Renewable Energy; H_2: Hydrogen
Source: Authors' analysis

About this Report

Clean hydrogen has the potential to play a significant role in decarbonizing energy and achieving climate goals, notably by decarbonizing certain energy-intensive industries and transport applications that cannot be electrified. The term clean hydrogen encompasses two types of hydrogen: (1) low carbon hydrogen (also known as *blue* hydrogen), produced from fossil fuels accompanied by carbon capture and storage (combustion based) or carbon storage (pyrolysis based); and (2) renewable hydrogen (also known as *green* hydrogen), produced via water electrolysis, using renewable electricity or using biomass. Neither type of clean hydrogen is widely deployed today; together they account for about 2 percent of total hydrogen production. Many projects are under development, but major upscaling is needed.

Context of the Report

There are multiple reasons why clean hydrogen deserves attention from a development perspective. First, electricity from renewable power generation sources will become the fundamental basis of our future energy system. Hydrogen is a clean energy vector that can transmit low-cost renewable electricity across time and space. This will be an indispensable part of any large energy system in the future. As noted above, clean hydrogen and its derivatives can be used to apply renewable electricity to the decarbonization of hard-to-abate sectors in industry and transport.

Second, energy-intensive industries tend to locate where energy is abundant and cheap. Clean hydrogen thus raises the industrialization potential of countries with abundant renewable energy resources. Already, ammonia and steel producers with roots in coal- or gas-producing areas are seeking out low-cost locations worldwide.

Third, first movers will gain critical experience early on. They will be able to claim relatively large shares of the limited amounts of concessional finance available and gain a foothold in supply chains in a sector that shows exponential growth. Possessing critical infrastructure before others and joining global supply chain networks early will create economic opportunities that may become more difficult to capture later.

Fourth, renewable hydrogen production is capital intensive. EMDCs will require vast amounts of financing to develop their hydrogen economies. As a rule-of-thumb, producing 1 million tonne (Mt) of renewable hydrogen per year requires approximately 10 GW of electrolyzers, 20 GW of renewable power, and $30 billion in investments. Policies that support clean hydrogen deployment through public and private investment need to be crafted in such a manner that hydrogen financing by MDBs is scaled up dramatically from the current level of less than $5 billion annually in EMDCs.

Fifth, clean hydrogen is based on new technologies with high perceived risk, which can push up the cost of capital in EMDCs, where financing costs are already generally higher. Given lack of experience in designing and implementing clean hydrogen projects, investors will require a risk premium. Higher financing costs, in combination with high capital intensity, complicate the business case for clean hydrogen. This situation needs to be shifted to a virtuous cycle in which new deployments result in technology learning, which, in turn, accelerates deployment, as has already occurred for solar and wind energy production.

Sixth, public intervention is needed in order to overcome both the wide funding gap on the supply side and high switching costs (costs incurred for replacing current end-use technologies with hydrogen) on the demand side. Public authorities and national governments have an essential role to play in pursuing these goals, as do public policy banks.

Rationale and Objective of the Report

This report proposes actions to ramp up clean hydrogen investments in EMDCs. It identifies barriers to accessing financing for clean hydrogen projects and identifies best practices for accelerating hydrogen deployment. Furthermore, it recommends key government actions that can serve as a basis for political commitment and strengthened bilateral and multilateral coordination at the global, national, and institutional levels. The report presents vital new information gathered through stakeholder interviews and surveys, supplemented with analyses of projects, and drawing on a wide range of public and internal sources. Because the sector is very dynamic and fluid, all information presented here must be considered in light of its source and date.

This report will serve as guideline to increase and strengthen the support for clean hydrogen that the World Bank is already providing to EMDCs. ESMAP launched the Hydrogen for Development (H4D) partnership at COP27 to promote knowledge sharing, capacity building, and financing in EMDCs. This report has benefitted from the valuable inputs and suggestions of H4D partners. In the financing sphere, as of June 2023, the World Bank Board had approved two lending operations, a $1.5 billion development policy loan in India and a $150 million investment project loan in Chile. This report will inform future investment decisions of the World Bank and other MDBs.

The report recommends a collaborative approach led by governments to tackle today's financing gap. As of August 2023, only 10 percent of global projects under development have reached the stage known as "final investment decision." Despite the fact that governments worldwide are committing more than $100 billion to financing and support clean hydrogen projects, the bulk of this financing is concentrated in developed countries, and available funds are insufficient to make hydrogen energy economically viable in the long term. It is imperative that we choose the most effective and efficient mechanisms to close the financing gap and overcome the first movers' risk.

Project financing depends on good policy frameworks. Governments must build enabling frameworks to stimulate demand, develop infrastructure, create an economically viable hydrogen market, and reduce the risk perceptions of developers and investors. These public policies may include fiscal instruments, binding net-zero commitments, and emission targets. Policies are also needed to scale up and transform clean hydrogen markets.

The report also recommends that government support and international concessional financing focus on the initial development stage. The level of risk decreases as projects move into the construction and operation phases. Blended finance is a possible solution, but it is not a one-size-fits-all remedy.

The report concludes that MDBs can play a defining role in kickstarting clean hydrogen project investments in EMDCs and are critical in unlocking private capital by providing innovative financing schemes and de-risking mechanisms. MDBs are likewise well positioned to provide technical assistance supporting the legal, regulatory, and institutional frameworks required to enable investments in the nascent clean hydrogen industry. They can also share best practices with client country governments, build institutional knowledge, and facilitate learning as clean hydrogen projects are financed and implemented. To increase the share of successful projects in the hydrogen sector, it is critical that every project be monitored, and best practices and failures documented.

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