INDIA ENERGY FACTSHEET

TEPA in Action: Opportunities for Iceland-India Energy Collaboration

Iceland

Embassy of Iceland
New Delhi

Nordic Council of Ministers

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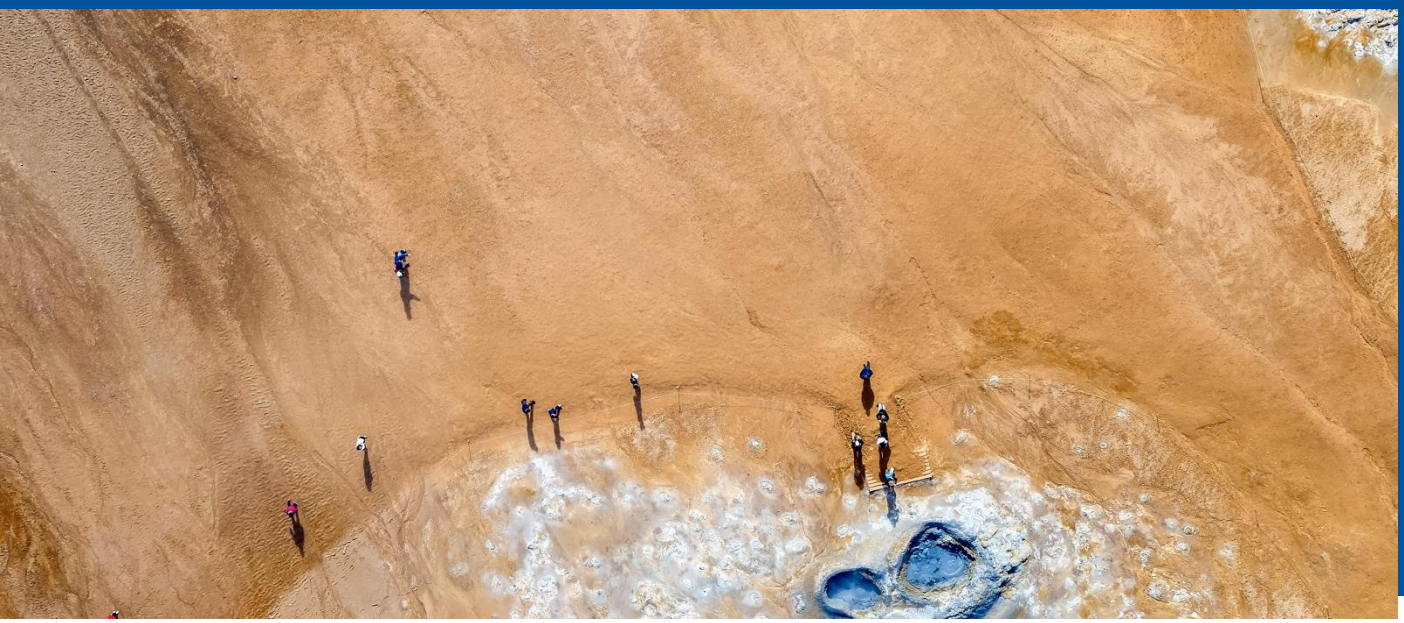
The Trade and Economic Partnership Agreement (TEPA) between India and the European Free Trade Association (EFTA)—comprising Iceland, Norway, Switzerland, and Liechtenstein—entered into force on October 1, 2025, opening transformative opportunities for Icelandic exporters in India's market of 1.4 billion consumers. India and Iceland share stable and constructive bilateral relations, supported by positive diplomatic ties and growing economic engagement. However, bilateral trade remains modest and underpenetrated, relative to the scale and growth potential of the Indian market.

At present, Iceland's exports to India remain concentrated in a limited set of specialized minerals, equipment, marine technologies, and niche energy solutions. TEPA is expected to improve market access and regulatory clarity, creating more predictable conditions for Icelandic firms to expand and diversify their engagement.

Under this agreement, over 200 energy sector-related tariff lines, corresponding to 57, 6-digit HS codes, have been identified to receive preferential tariff reductions and eliminations.[1] Iceland demonstrates established export competitiveness and global market presence in 37 strategically important 6-digit HS codes, representing 150+ tariff lines.[2] These products constitute Iceland's primary areas of commercial strength and offer the most immediate and substantial opportunities for market entry and expansion in India.

- *India has committed to providing tariff concessions on approximately 82.7% of its tariff lines. These lines account for roughly 95.3% of the total value of EFTA exports to India.[3]*
- *Reciprocally, EFTA countries will eliminate duties on 92.2 % of India's exports (99.6 % of value)[4]*
- TEPA encompasses 14 comprehensive chapters beyond tariffs, including investment mobilization, intellectual property, government procurement, and sustainable development provisions.

1, 2. T&A's consulting's internal analysis based on itctrademap.org data
3, 4. India-EFTA Trade Pact: Boosting $100 Billion Investment and 1 Million Jobs, Press Information Bureau – Oct 2025



India's energy ambition and needs

India is the third-largest producer and consumer of electricity worldwide, with an installed power capacity of 509 GW in 2025.[5] Although power generation has grown more than 100-fold since independence, growth in demand has been even higher due to accelerating economic activity. India's energy demand is expected to grow 6% annually over the next five years.[6]

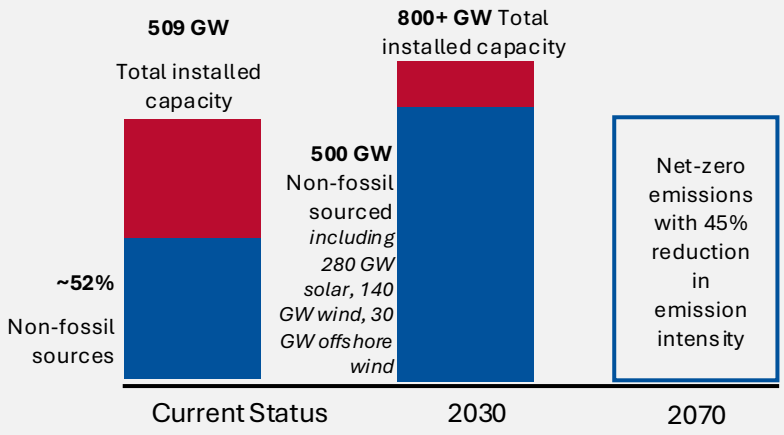
India's industrial expansion and strong GDP growth are expected to increase India's power requirement to **817 GW by 2030.**[7]

India's energy transition ambition is driven by the need to secure energy independence from fossil fuel import and focus on industrial decarbonization across hard-to-abate sectors including steel, cement, chemicals, and fertilizers, positioning energy transition as both an economic imperative and climate leadership opportunity.

To accommodate the growing need, India pivoted towards its energy transition ambition to reach 500 GW of non-fossil energy capacity by 2030 and net-zero by 2070.

India's energy transition ambition and its current status

In 2025, India added a record 35 GW of solar capacity, taking its installed solar capacity to 132 GW.



Source: Press Information Bureau (Government of India), December, 2025

Non-fossil sources contribute to **~52% of the total installed capacity**, as of November 2025.[8]

India's renewable energy capacity surged **420% YoY in November 2025, with solar reaching 132 GW, wind 54 GW, hydro reaching 55 GW, and bio energy reaching 12 GW.**[9]

To meet its growing needs, India has established one of the world's most competitive FDI regimes, offering 100% foreign investment under automatic route with no government approvals required and equal treatment with domestic players.

Energy accounted for **~3% of the total FDI flows until March 2025.**[10] As of March 31, 2025, India received ~USD 13 billion in FDI in the renewable energy sector, reflecting strong investor confidence and growth prospects.[11]

5, 6, 8 . Ministry of New and Renewable Energy India, Central Electricity Authority, Government of India
9. Press Bureau of India (PIB), Ministry of New and Renewable Energy India
10, 11. Department for Promotion of Industry and Internal Trade of India, Government of India

Iceland GeoSurvey (ÍSOR) in partnership with Oil and Natural Gas Corporation (ONGC) India, engineering firm Verkís and the Indian company Techon Consulting, are engaged in the development of the first geothermal power plant in the Puga Valley in Ladakh.[12]

Further to FDI facilitation, India has deployed comprehensive financial mechanisms to accelerate renewable energy investments. The government provides support in the form of Viability Gap Funding (VGF) to support economically challenging but strategically important projects; Sovereign Green Bonds providing long-term concessional financing, and Accelerated Depreciation schemes offering tax benefits for renewable investments.

The government is further developing Carbon Trading Mechanisms to support carbon capture, utilization, and storage (CCUS) and broader emission reduction initiatives, creating a multi-layered financial ecosystem designed to de-risk and incentivize clean energy transitions.

Iceland, a strategic partner for India

Meeting India's energy transition ambitions will require substantial investment in transmission lines, grid management, energy storage, offshore infrastructure, and innovative technologies, areas where Icelandic expertise is particularly strong. The elimination or reduction of import duties across Energy sector oriented products under TEPA is expected to make Icelandic exports cost-competitive in India's energy supply chain.

Iceland's energy sector capability is underpinned by its domestic power system, where electricity generation is 100% renewable, with approximately 70% from hydropower and 30% from geothermal energy, providing real-world operational experience.

Geothermal Energy

India's need	• Estimated power generation potential: 10 GW across 10 geothermal provinces, 381 identified hot springs, and potential to repurpose thousands of abandoned oil/gas wells.[13]
	• Technology deficit: Absence of deep drilling expertise, and a **need to tailor drilling tech for varying permeability and porosity, along with resource categorization and reservoir conceptualisation challenges.**
	• Pilot stage projects and need for operational expertise:
	  ▪ India is currently advancing pilot projects in regions such as the Himalayas and the Cambay Basin, where operational experience remains limited.
	  ▪ Need for **technological expertise in repurposing of abandoned/ mature oil and gas wells** for geothermal.
	• Direct utilization: Geothermal energy for applications such as **space heating, agricultural and horticultural drying, cold storage, and spa or tourism projects,** offers a more practical and near-term pathway than power generation in many regions.
	  ▪ Apple farmers in Himachal Pradesh lack cold storage, forcing harvest sales at low prices. geothermal cooling could transform agricultural economics.
	  ▪ Need for year-round vegetable cultivation in high-altitude regions where conventional energy is unreliable and expensive.

Icelandic strength alignment	• Iceland is a pioneer in the use of geothermal energy for space heating with over a century of experience in utilizing geothermal energy. • Geothermal power facilities currently **generate 30% of the country's total electricity production** . • Iceland's expertise lie in **geothermal systems, subsurface engineering, and project development - spanning both power generation**. ÍSOR has secured one of its largest international contracts for the Puga Valley project, providing consulting in drill preparation, research, monitoring, measurements, and data processing. • Borehole repurposing expertise: Iceland's experience spans both **greenfield geothermal development and optimizing existing wells**. ONGC's MoU with ÍSOR covers geothermal exploration enabling systematic assessment of existing borehole networks. • **Direct-use geothermal application including district and space heating, agricultural and horticultural drying, cold storage, and tourism-linked uses, align well** with India's geothermal pilots and position Icelandic companies as natural partners in the scale-up phase of low-to medium enthalpy geothermal resources.

12.. Press release by Government of Iceland
13. Press Information Bureau (Government of India), December 2025

Carbon Capture, Utilization, and Storage (CCUS)

India's need	• Target capacity: 750 million tonnes of CO_2 capture per year by 2050 with an investment requirement of ~USD 150 billion.[14] • Market momentum is largely driven by government-level sustainability commitments, including net-zero targets, industrial decarbonization objectives, and the need to address emissions from hard-to-abate sectors such as steel, cement, refining, and fertilizers. • **India has launched the first-of-its-kind R&D roadmap in December 2025 to enable the country's net-zero emission targets of 2070 through CCUS**.[15]
Icelandic strength alignment	• Iceland hosts **breakthrough CCUS applications** that enable the **permanent mineralization of CO_2 into stone** through injection into basaltic rock formations, as well as **carbon recycling pathways that convert captured CO_2 into methanol and other low-carbon fuels**. Together, these solutions address emissions from hard-to-abate sectors and direct air capture, offering both permanent storage and productive utilization routes.[16] • In contrast to India's pre-commercial CCUS landscape, Iceland has developed real-world, commercial-scale CCUS capabilities, underpinned by its geology, renewable power base, and strong public–private collaboration, with a clear focus on permanent geological storage. • Iceland has demonstrated large-scale CCUS capability through **Mammoth, one of the world's largest carbon capture and storage facilities**, which integrates direct air capture with renewable-powered operations and permanent mineral storage in basalt formations, serving as a global reference for commercial-scale CCUS deployment.[17]

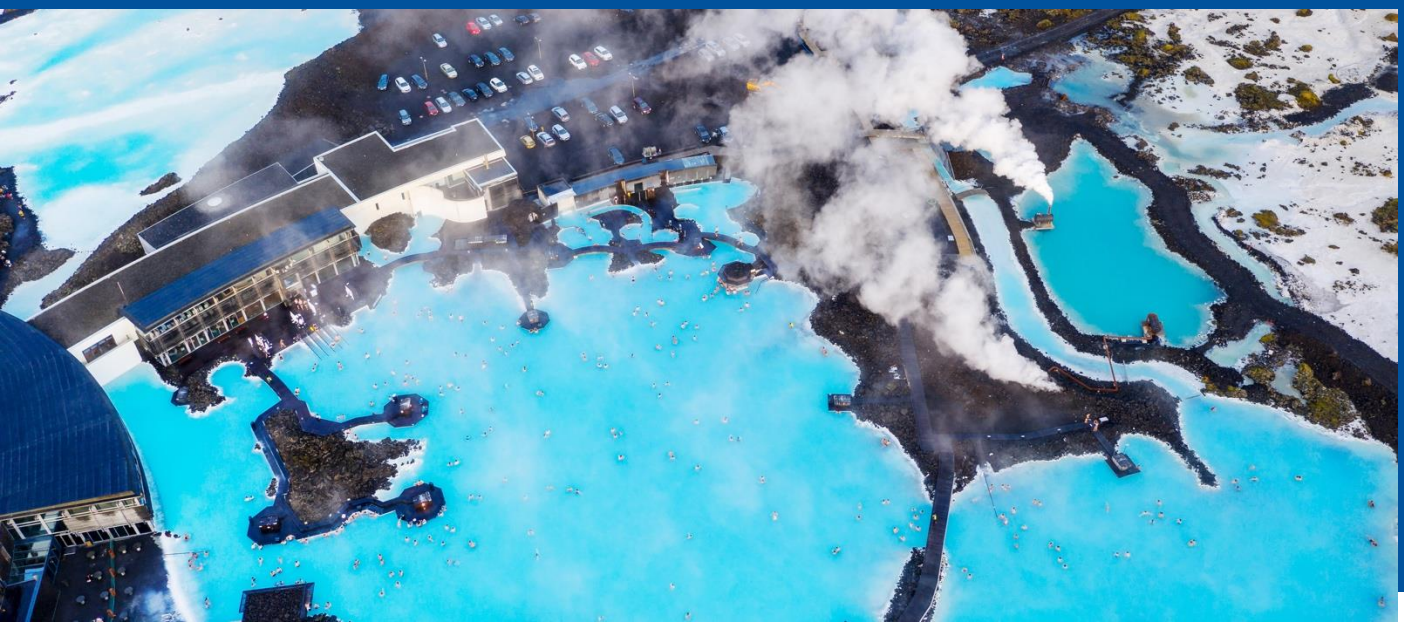
Wind Energy

India's need	• Capacity gap: Estimated offshore wind potential of 70 GW across Gujarat and Tamil Nadu coast, but zero operational capacity. First 4 GW tender rolled out in 2024.[18] • Technology deficit: Absence of domestic supply chains leading to a lack of turbine models suited for Indian regimes, and a need for specialized vessels, installation equipment, and grid integration.
Icelandic strength alignment	• Iceland is actively building capabilities in **floating offshore wind**, drawing on its long-standing experience in marine engineering, grid integration, and cold-climate energy operations; while no offshore projects are currently operational, this groundwork positions Iceland strongly for future offshore wind development. • Iceland has demonstrated high-tech capability through projects such as the **Búrfell wind project** in southern Iceland, developed by **Landsvirkjun, Iceland's state-owned power company**. The **120 MW project**, the country's first large-scale wind farm, leverages existing hydropower infrastructure to reduce environmental impact and construction costs, with operations expected around **2026–2027**.[19]

Energy Storage & Batteries

India's need	• Large deficit: The Central Electricity Authority estimates that India will require approximately 336 GWh of energy storage capacity by 2029–30 and 411 GWh by 2031–32 to support reliable renewable integration.[20] • BESS: Large-scale battery energy storage systems (BESS) are emerging as a critical enabler of India's power transition, particularly for integrating variable renewable energy and strengthening grid stability • Further strengthening the market potential, **India's Electricity Rules were amended in December 2022 to explicitly recognize Energy Storage Systems (ESS) as an integral part of the power system**[21], enabling their participation across generation, transmission, and distribution functions.
Icelandic strength alignment	• Iceland's strengths lie in power electronics, grid-forming inverters, and system architecture that enable stable operation of storage assets within renewable-dominated power systems. • Iceland brings Proven capabilities in **BMS design, thermal control, and safety frameworks** support reliable, long-duration operation of large-scale BESS. • Strong Expertise in real-time monitoring, control systems, and grid integration positions Icelandic expertise to support India as BESS scales from pilots to a core power-system asset.

14. Carbon Capture, Utilization, and Storage (CCUS) - Policy Framework and its Deployment Mechanism in India – NITI Ayog (2022)
15. India launches R&D roadmap for carbon capture tech to enable its net zero goal (Times of India), December 2025
16. Websites of Carbfix, Carbon Recycle International
17. Iceland's 'Mammoth' raises potential for carbon capture (The Hindu) – May 2024
18. Press Information Bureau (Government of India), February 2024
19. AFRY Press Release (January 2025) AFRY provides technical consultancy for Iceland's first large-scale wind farm
20, 21. Press Information Bureau (Government of India) – December 2025



Impact of TEPA

The India-EFTA TEPA transforms the natural Iceland-India energy alignment into a structured, institutionalized partnership by reducing tariffs, easing barriers, and enabling Icelandic companies to move beyond exports into local presence, joint ventures, and technology partnerships.

To understand the impact of TEPA and the opportunities it provides, data on Iceland's export strengths, India's import demand, and India's tariff commitments were analysed to translate policy provisions into actionable market-entry insights.

- All HS 6-digit level codes were compiled along with their corresponding tariff lines to identify and shortlist energy sector-related chapters and codes.
- For the TEPA benefit type offered by India, a 1-10 scoring scale was applied based on the degree of market access improvement, with immediate tariff elimination (EIF) scoring highest (10) and other provisions such as E5 and E7 receiving progressively lower scores.
- For Icelandic export strength and Indian import demand, scores were assigned using quartile-based thresholds derived from the data distribution. Upper and lower quartile thresholds were used to allocate scores from 1 (low or unfavorable) to 10 (highly favorable).
- The final composite opportunity score was calculated using weighted contributions of 50% for Iceland's export strength, 25% for India's import demand, and 25% for the TEPA benefit type.

Export opportunity potential of Icelandic origin energy product lines after TEPA implementation

Geothermal Energy:

- *According to the International Energy Agency, India is among the three largest global markets for next-generation geothermal electricity. Market potential is estimated to reach 4.2 GW by 2035 and nearly 100 GW by 2045.*[22]
- *Key geothermal zones include the Himalayan Geothermal Province, the Cambay Graben in Gujarat (home to abandoned oil wells suitable for repurposing), and the Andaman and Nicobar Islands.*
- India has strong potential for direct utilization of geothermal energy, particularly for heating, cooling, agricultural processing, and tourism-linked applications

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
848180	Geothermal Steam Valves, Expansion Valves And Solenoid Valves, Specialized Thermal Expansion & Regulating Valves	Moderate	• Industrial valves, including iron/steel taps and cocks, non-ferrous fittings, and general industrial valves, enjoy a seven-year duty elimination (E7) • Highly specialized valves (such as inner tube valves) follow a longer ten-year phase-out (E10)
843143	Parts for Drilling Rigs, Wellhead & Control Parts, Maintenance Spares	Moderate	• All the parts for boring or sinking machinery are subject to a ten-year duty elimination (E10) under TEPA.

22. *International Energy Agency Estimates*

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
841370	Submersible Pumps, Single and Multistage Chemical Process Pumps, Horizontal Split Casing Pumps, Boiler Feed Pumps	Moderate	• Technologies like Single and Multistage Chemical pumps and Vertical Turbine pumps enjoy a seven-year duty elimination (E7). • All other specialized centrifugal pumps follow the same E7 timeline, while general water-handling pumps see a slower ten-year phase-out (E10)
842139	Steam-Brine Cyclone Separators, Gas Purification Systems, Electrostatic Precipitators	Low - Moderate	• Under the TEPA, Air separators and strippers benefit from a five-year duty elimination (E5). • Other auxiliary gas purification units follow a ten-year duty elimination (E10) schedule.
901580	Geophysical Instruments (seismographs, magnetometers, gravity meters)	Moderate - High	• Geothermal exploration tools like, geophysical and general surveying instruments, enjoy a Seven-year duty elimination (E7) • hydrographic instruments receives no benefits • Other miscellaneous instruments enjoy a gradual 10-year duty elimination (E10)
843049	Geothermal Drill Rigs, Horizontal Directional Drilling (HDD) Units	High	• 'Other' boring or sinking machinery is subject to a ten-year duty elimination (E10), progressively reducing the standard duties in India to zero by 2035.
843041	Self-Propelled Geothermal Drilling Rigs, Tube Well and Core Drilling Machinery, Rock Drilling Machinery	Moderate	• Self-propelled boring or sinking machinery is subject to a ten-year duty elimination (E10), progressively reducing the standard duties in India to zero by 2035.

Opportunities under TEPA are concentrated in geothermal valves, pumps, and flow-control equipment's, gas separation and purification systems, and geophysical and exploration instruments. Selected geothermal applications such as heat-exchange units do not benefit from TEPA tariff concessions. However, TEPA's Rules of Origin specify that exported products must either be wholly obtained or sufficiently worked or processed in Iceland, for all tariff concessions to be applicable.

Therefore, technology licensing and engineering know-how is identified as the primary exportable value rather than manufactured. Iceland's strongest value proposition lies in knowledge collaboration, particularly in subsurface risk assessment, exploration methodologies, reservoir modelling, drilling best practices, system design, and capacity-building support for India's pilot and early-stage geothermal projects.

Offshore and onshore wind energy:

- *Already identified offshore wind zones along the Gujarat and Tamil Nadu coasts create medium-term opportunities primarily for services-led collaboration, including feasibility studies, system design, marine and grid-integration engineering, and operational planning.*
- *Policy push: The National Offshore Wind Energy Policy provides a roadmap to auction 37 GW of seabed leases by FY 2030.* [23]

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
850300	Generator Components, Structural & Housing Parts, Motor Parts	Moderate	• Specialized and miscellaneous parts of generators (AC / DC) enjoy the fastest path to market with a five-year duty elimination (E5) • Other general turbine infrastructure, including parts of DC motors follow a ten-year duty elimination (E10)
841280	Wind Turbines and Wind Mill Engines	Low - Moderate	• Stationary power units benefit from a seven-year phased duty elimination (E7), progressively reducing the duty to zero in India.

Opportunities are centered on specialized AC/DC generator parts, with turbine infrastructure and DC motor components, stationary power units. Wind-powered generating sets (HS 850231) are excluded from TEPA and therefore receive no tariff concessions. Although TEPA grants duty benefits for wind tower structures and transmission masts (HS 730820), Iceland currently lacks export capability in this segment.

Therefore, strong opportunities exist in niche system components, digital monitoring & surveillance, condition-based maintenance, and lifecycle optimization, where Icelandic firms can differentiate through expertise in reliability-focused system design and operations in harsh and remote environments.

However, all exported products must align with TEPA's Rules of Origin—exported products must either be wholly obtained or sufficiently worked or processed in Iceland—for all tariff concessions to be applicable.

22, 23. Harnessing India's Potential in Offshore Wind Leasing - www.orfonline.org (June 2025)

Carbon Capture, Utilization, and Storage:

- *Carbon Capture, Utilization, and Storage (CCUS) is still at a nascent & pre-commercial stage in India.*
- *Early demand is driven by India's Public Sector Undertakings such as ONGC, NTPC, and IOCL, which are undertaking feasibility studies, pilots, and subsurface assessments.*
- *These entities are expected to anchor initial CCUS deployment before private-sector uptake expands.*
- *Key market constraints include the absence of a carbon pricing mechanism, limited CO_2 transport and storage infrastructure, and evolving regulatory clarity.*

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
841989	Process Tanks and Vessels, Heating and Cooling Apparatus, Cooling Towers and Plant Equipment.	Low - Moderate	• Pressure vessels, reactors, distillation columns, and storage tanks are currently excluded from tariff reductions under TEPA. • Vacuum-vapour plants will see their Customs Duty phased out in seven years (E7). • Specialized infrastructure such as cooling towers and other miscellaneous industrial plants enjoy a gradual ten-year path to duty-free status (E10).
842129	Solvent Filtration Systems, Contaminant Removal Units, Water-Solvent Separation Filters, Hydraulic Fluid Filters	Low - Moderate	• Machinery for filtering or purifying liquids is subject to a ten-year duty elimination (E10), meaning the current Customs Duty will be phased out gradually until it reaches zero.
842139	Gas Purification Systems, Electrostatic Precipitators, Co2 Separation Units	Low - Moderate	• Air separators and strippers benefit from a five-year duty elimination (E5). • Other auxiliary gas purification units follow a ten-year duty elimination (E10) schedule.
902610	Flow Meters, Liquid Co2 Level Gauges	Low - Moderate	• Under the TEPA, all major sub-lines of this category, including flow meters and level gauges, enjoy a gradual seven-year duty elimination (E7)

CCUS related opportunities are concentrated in gas purification and CO_2 separation equipment, liquid and solvent filtration systems, and measurement and monitoring instruments such as flow meters and CO_2 level gauges. However, lack of export prowess and TEPA 's Rules of Origin delimit good export opportunities if non-originating inputs dominate the production chain.

On account of its nascent nature, the actual opportunity area for Icelandic companies lie in licensing of CCUS and renewable methanol technologies, process engineering, and system design support. Opportunities in services include feasibility studies, subsurface storage, carbon mineralization technology for India's Deccan Trap basalt formations, technology collaboration in turning carbon dioxide into stone, monitoring and verification (MRV) frameworks, system design, and pilot-phase operational support.

Energy Storage and Batteries

- *As India rapidly scales solar and wind capacity, grid-connected storage is increasingly required to manage intermittency, smooth peak demand, provide frequency regulation, and defer costly transmission upgrades.*
- *Utility-scale BESS projects, ranging from tens to hundreds of megawatt-hours, are now being planned and tendered alongside renewable generation and at key grid nodes.*
- *However, for certain product lines, India is pushing for domestic manufacturing to scale up and mature. This is evident in TEPA concessions of longer period elimination on lithium-ion batteries, battery chargers, and general battery parts.*

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
850440	directional Inverters / Power Conversion Systems, Industrial and Automatic Battery Chargers, Uninterruptible Power Supplies, Rectifiers	Moderate	• BESS components, specifically Dip Bridge Rectifiers and Voltage Regulators, enjoy an accelerated path to zero duty in 5 years (E5). • Electric Inverters, Battery Chargers, and miscellaneous Static Converters follow a gradual ten-year elimination schedule (E10).
850760	Lithium-ion battery modules and racks for large scale systems and UPS, Large-capacity battery packs	Low - moderate	• Lithium-ion batteries are subject to a ten-year duty elimination (E10).
760429	Bare Aluminum Conductors , ACSR (Aluminum Conductor Steel Reinforced) bars & rods	High	• Aluminium Conductors Steel Re-Inforced (A.C.S.R) enjoys a seven-year duty elimination (E7) under TEPA • Wire rods follow an accelerated five-year path to zero duty (E5).

Relevant HS Codes	Key Products	Alignment of Iceland's strengths with India's needs	TEPA advantage Interpretation
853710	Energy Management Systems (EMS) Panels, Low-Voltage Switchgear and Distribution Boards, Battery Charge Controller Panels	Moderate – High	• Electric Control or Distribution Boards (For A Voltage Not Exceeding 1,000 V) are subject to a ten-year gradual duty elimination (E10) under TEPA.

Under TEPA, Iceland's BESS-related export potential is concentrated in power electronics and static converters, battery modules and system-level packs, aluminium conductors and structural profiles, and energy management and electrical control panels. In contrast, artificial graphite and AC electricity meters are placed on India's Exclusion List and receive no tariff benefits

Iceland's service export potential lies in grid-enabling and auxiliary energy solutions that support reliable integration of storage and renewables. This includes high-voltage grid monitoring, condition and thermal assessment, digital surveillance, and data-driven asset management services, which enable real-time performance optimization, reduce outage risk, and strengthen the stability and efficiency of renewable-integrated power systems in India.

Trade in services: Provisions under TEPA

Prior to TEPA, Icelandic energy companies could export equipment to India and establish local subsidiaries under India's WTO-consistent trade and investment regime. However, the delivery of project-linked technical services, such as installation, commissioning, testing, and early-stage operational support, was governed primarily by domestic regulations rather than dedicated bilateral commitments. TEPA improves predictability by providing treaty-based assurances for services and professional mobility, which is particularly relevant for energy projects that rely on the seamless integration of equipment supply and specialized expertise.

Streamlined personnel mobility: Removes labour-market testing requirements, enabling Icelandic energy specialists (offshore wind engineers, subsea systems experts, CCUS technicians, grid-integration engineers) to enter India for up to three months per year through the "Installer or Servicer" category, improving project planning certainty for complex energy projects.

Bundled delivery model enablement: Provides treaty-based clarity allowing Icelandic companies to supply energy equipment together with integrated services (installation, training, commissioning, digital monitoring, maintenance) under coherent commitments, particularly critical for offshore wind farms, CCUS infrastructure, and advanced grid systems where equipment performance depends on expert service delivery.

Enhanced commercial presence and qualification recognition: Permits establishment of local engineering offices, service hubs, and project teams in India with national treatment protections, while mutual recognition of technical qualifications reduces regulatory friction for deploying Icelandic professionals in highly regulated energy activities, strengthening long-term service footprint and bilateral technical collaboration.

Overall Impact for Icelandic Energy Services

TEPA enables Icelandic energy companies to move beyond transactional exports and engage more deeply in India's energy transition as technology, systems, and knowledge partners. By facilitating the temporary entry of specialists, supporting recognition of technical qualifications, and ensuring national treatment for service suppliers, the agreement enables the delivery of Iceland's strengths in system design, subsurface and geothermal expertise, grid optimization, energy storage integration, CCUS feasibility and monitoring frameworks, and renewable system integration, alongside selective equipment supply. This supports a durable, services-led Icelandic footprint in India and strengthens bilateral collaboration across renewable, grid-connected, and emerging energy technologies.

Challenges

Early-stage and pilot-led market maturity: Across geothermal energy and CCUS, India remains in a largely pre-commercial phase, with policy frameworks focused on testing technical and commercial viability rather than enabling full-scale deployment. Geothermal development is still confined to pilots under the national policy, while CCUS activity is limited to feasibility studies and demonstrations led by public sector undertakings. This pilot-led approach slows market scale-up and constrains near-term demand for large equipment or turnkey solutions.

Evolving regulatory and standards environment: Regulatory fragmentation across multiple agencies—including the Ministry of New and Renewable Energy (MNRE), Ministry of Environment, state governments, and forest departments—creates complex approval pathways with overlapping jurisdictional requirements. The absence of a single-window clearance mechanism exacerbates these challenges, leading to project delays and procedural complexity that discourage foreign investment and technology partnerships.

Additionally, intellectual property protection risks remain a central concern for technology licensors considering market entry, requiring active mitigation strategies through carefully structured licensing agreements, partnership frameworks, and legal safeguards to protect proprietary technologies and know-how in an environment where IP enforcement mechanisms may be uncertain or inconsistent.

Economic constraints create significant barriers to emerging energy technologies in India through multiple interconnected challenges. High electricity prices undermine project economics for green methanol and electrolysis-based hydrogen, while limited biogenic CO_2 availability constrains renewable methanol feedstock supply. The capital-intensive nature of technologies like geothermal exploration requires substantial upfront investment with no immediate commercial returns, creating financing challenges in markets like India, expecting shorter payback periods. Most critically, a "patience gap" exists between Indian stakeholders demanding short-term outcomes and the multi-decade development timelines demonstrated in mature geothermal markets like the United States and Iceland, fundamentally limiting sustained commitment to technologies requiring patient capital and long-term experimentation before achieving commercial viability.

24. ALMM = Approved List of Models and Manufacturers rules, set by India's Ministry of New and Renewable Energy (MNRE)

Potential market entry routes

Pilot Project Participation

- Stakeholder interviews revealed that India's geothermal market is at an early resource assessment stage with no commercial projects.
- Private sector participation is absent due to lack of resource certainty. Pilot project participation addresses a critical "patience gap" - Indian stakeholders expect short-term outcomes whereas mature markets (Iceland, US) evolved over decades.
- Target areas:
  - PSU-led experimental projects with ONGC and Oil India for power generation demonstrations; for hybrid cascading-use models; direct heating pilots in Himalayan regions requiring heating for 7-8 months annually.
- Partnership formats:
  - Technology collaboration agreements with PSUs;
  - Resource assessment and validation services;
  - Drilling expertise provision through rig leasing arrangements
- Time consideration: Mobilization requires 70-80 containers and a 6-12 month lead time.

Technology Licensing and Advisory Services

- Target areas: Deep drilling technology collaboration; reservoir characterization and resource categorization; subsurface monitoring systems; cascading-use system design for district heating, greenhouses, cold storage, and tourism applications.
- Modalities:
  - Engineering service agreements with Indian partners
  - Advisory support for borehole repurposing from abandoned oil/gas wells
  - Training and capacity building programs aligned with GRÓ GTP fellowship model.

Iceland retains

- **Technology license**
- **Proprietary process design**
- **Core engineering and system engineering services**
- **Value-added engineering services**

India sources locally

- **General equipment**
- **Construction and general engineering products**
- **Plant equipment**

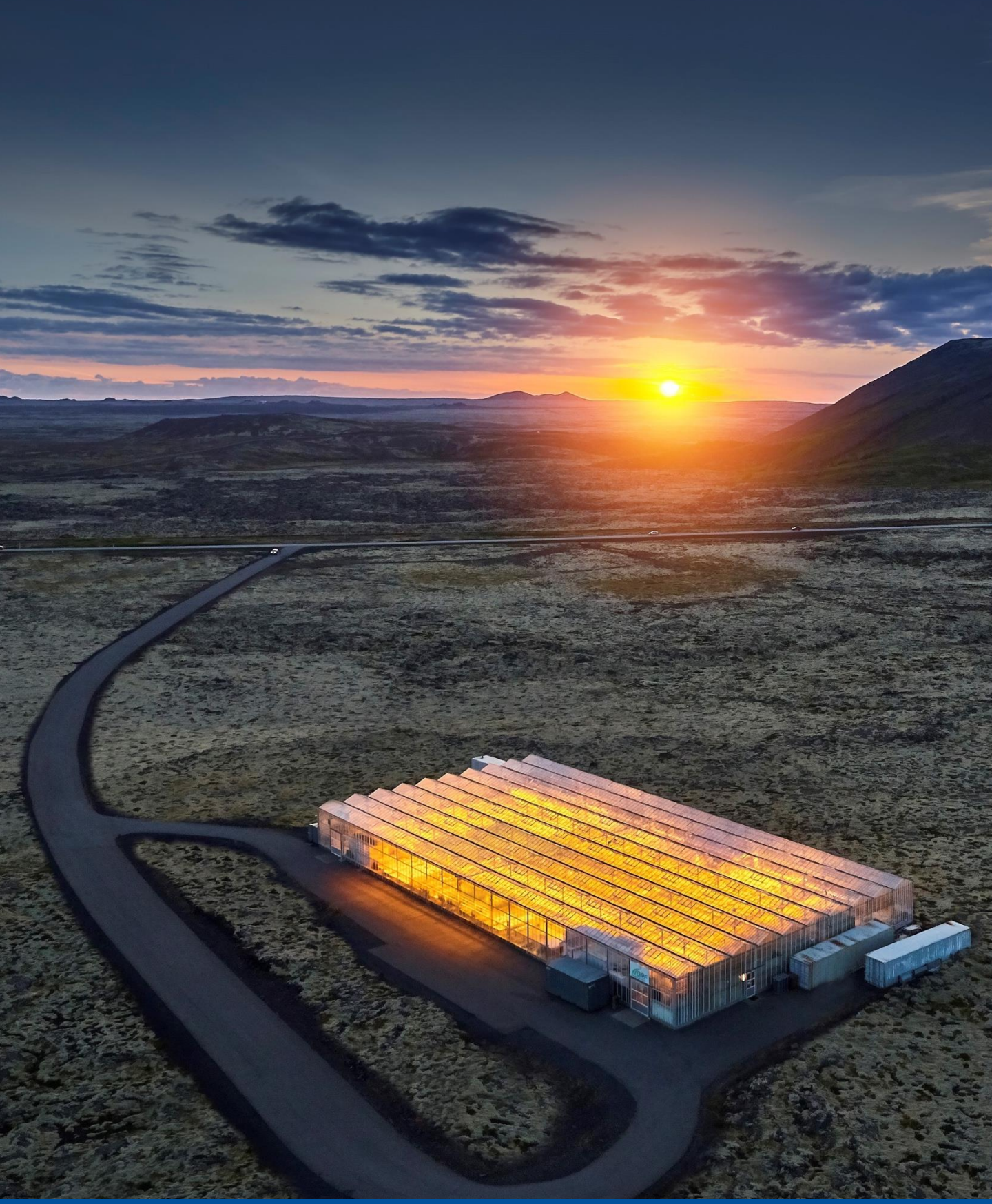
Partnership structure

- **Indian engineering firms execute construction**
- **PSUs provide capital and project ownership**
- **Technology owner retains IP and process control**

Direct Utilization Project Development (Geothermal)

Direct utilization offers a more practical and near-term pathway than power generation for India's low-to-medium enthalpy geothermal resources. Himalayan regions face a large, unmet demand for space heating and other cascading heat applications across multiple end-use scenarios.

- Target areas: Space heating for army installations and residential areas; agricultural cold storage (horticultural drying facilities; greenhouse heating for year-round vegetable cultivation; snow melting for strategic roads; spa and tourism development.
- Modalities:
  - State government partnerships (Himachal Pradesh, Uttarakhand models)
  - Co-development with local communities under SDG partnership funding;
  - Vapor absorption cooling technology collaboration for cold storage applications.



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