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# ENERGISING INNOVATION: THE ROLE OF GLOBAL INNOVATION ALLIANCES IN ADDRESSING KEY ENERGY CHALLENGES

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***Abstract*— Innovation in the global energy sector is increasingly imperative to buttress economic and environmental sustainability moving forwards. Negative resource trends, climate change and rising energy demand mean that finding innovative solutions to lessen our reliance on traditional sources is increasingly vital. Enabling innovation alliances between low-income developing countries and the developed world is essential for both to gain maximum benefit from upcoming energy technologies while also creating solutions to key global energy challenges.**

**This study will establish the scope for global innovation alliances in the energy sector in order to maximise the return on investment and sustainable impact. It will utilise case studies to demonstrate the success of international collaboration in this critical and growing industry. Furthermore, it will examine the role of summits such as the G20, which are often ideal forums to form strategic innovation alliances, as well as develop policies to incentivise ongoing relationships between developing and developed countries in this sector.**

## I. Introduction

Around the world countries are increasingly investing in product, process and business model innovation across all sectors. This is a widely recognised strategy to increase stability and resilience in uncertain economic climates. Simultaneously, issues regarding environmental sustainability are of growing urgency to the International community, which is largely at the mercy of our natural resources. Furthermore, this is also an issue of economics, inclusiveness and social equality, as demonstrated by the 18% of the world's population that currently lacks access to electricity [1]. For the more fortunate, prices continue to rise and the environmental repercussions of accessing increasingly scarce resources continue to worsen.

The energy challenge is widely cited as one of the fundamental trials facing the global community today [1-4] and therefore requires innovative global solutions. The market realises the importance of innovating in this sector, highlighted by the global energy research and development (R&D) expenditure of US$21 billion a year [5], growing at 4.8% annually [5]. This spending growth, however, is not matched in the adoption of alternative energy sources, which indicates that further effort is necessary. Given the universal nature of the issue, international summits such as the G20 are well positioned to aid in the development of such solutions. It is crucial that international bodies are willing to take an action-based role in forming alliances and driving consensus on key issues including energy efficiency. The shift to a more pro-active use of these forums is critical for their sustained impact and validity from a global perspective. These summits have the potential to be a key driver in balancing this precarious equation to ensure a sustainable future for both our global environment and economy.

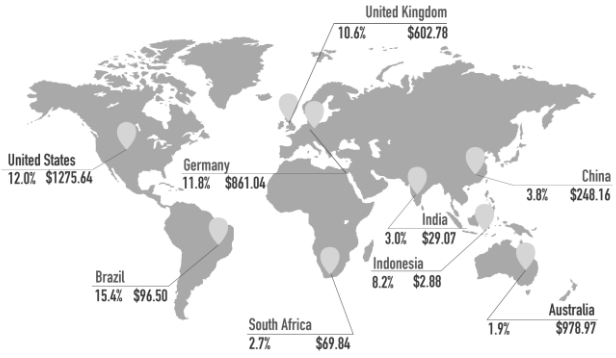


Fig. 1. Alternative energy use (%) and R&D Expenditure per capita ($US) [6]

## II. Defining Innovation

Prior to investigating the scope for international innovation alliances, it is important to clarify the often-misinterpreted definition of innovation. The Commonwealth of Australia's Innovation Agenda explains that the definition of innovation is broader than commonly assumed. It states "*there is much more to innovation than laboratory R&D…Improvements to the way we organise, manage, operate, and market things are equally important*" [7]. In the energy sector it is particularly necessary to adopt this broader interpretation as even minor improvements in the management of resources can have significant impact [2]. Furthermore, it is important to identify

the importance of innovating across the support services adjunct to a company's core competencies in energy, such as marketing and distribution [8].

It is, however, also vital not to over broaden the definition and to therefore recognise the disparate distinction between invention and innovation [8]. Invention is commonly defined as the solution to a problem, whereas innovation is the commercially successful use of the invention. This commercialisation is a crucial factor that is currently preventing many highly creative inventions in low-income developing countries from realising their full potential for impact as innovative solutions [2]. This strongly supports the value proposition of global alliances in this industry. Further to this, it bolsters the case for stronger collaboration between research institutes and industries, both locally and on an International level.

A more quantitative definition can be drawn from the Bloomberg 2015 Innovation index, which evaluated six practical criteria in order to rank the top 50 most innovative countries globally [9]. This view of analysing a country's innovation capacity is useful in developing a model for global innovation alliances as it validates key metrics that should be compared and evaluated by participating parties. Its secondary aim was to evaluate if there was a quantifiable and replicable formula for innovation. This would add significant value to the proposition of any international collaboration, but may also reduce the willingness of some parties to share knowledge and innovation expertise.

The first assessable area of the Bloomberg 2015 Innovation index was R&D spending as a percentage of GDP [9]. The Commonwealth of Australia also supports this theory, highlighting that research and development (R&D) expenditure is indicative of a company or sector's investment in innovation [7]. Frugal innovation, however, is fundamentally challenging this presumption with the success of innovations produced with very low R&D expenditure.

The second criterion examined was the manufacturing value added per capita. This measure specifically targets product development innovation [9]. The 'per capita' analysis here is important as it distinguishes truly innovative manufacturing nations from other countries like China, which possesses a significant manufacturing sector but a large population and aging technology in this industry [9]. This is clearly a critical factor for cutting edge innovations in the energy sector, however, many of the 'frugal' innovations developed in India and China to do not rely on this capability. They frequently keep costs to a minimum by using readily-available materials, and bulk existing manufacturing resources [10].

The Bloomberg Innovation Index then calculated the total number of domestically domiciled high-tech public companies as a share of the world's total high-tech public companies. This factor defined the somewhat ambiguous term 'high-tech'. Bloomberg included renewable energy in this metric, which reinforced the significant value of innovation in this sector. This was the only ranking that was not scaled to each individual company's economy or population, which shed light to the unequal distribution of technology firms, highlighting that 90% of the top 10 largest technology companies were US based [9].

Postsecondary education was another factor that was crucial to consider. This is often the root of the perceived disparity between the innovation capability of developed and developing countries [11]. This factor involved considering a number of sub-indexes that were all relevant to accurately rank the country's innovation success. These included the number of secondary graduates enrolled in postsecondary institutions as a percentage of cohort, the proportion of the labor force with tertiary education, and an analysis of the annual science and engineering graduates within both the entire labor force and as the total tertiary graduate pool [9].

Following on from this, the research personnel were evaluated by calculating the professionals engaged in R&D per 1 million population. Again, this metric does not credit frugal innovators producing and commercialising ideas without educational qualifications [12]. This disparity could, however, add value to the model of global innovation alliances as these are often developed based on complementary core competencies [13]. In this case, the technical expertise of research personnel could be an ideal pairing with the practical and pragmatic knowledge and understanding of large market segments that a less developed country could provide.

The final measure in this study was regarding patents filed, which can be considered a mixed blessing in the context of innovation. Although they serve to protect new ideas and encourage commercialisation, they can also limit progression. By encouraging secrecy rather than an open flow of communication between ideators, these frequently prohibit innovators from accessing details that would allow them to improve existing technologies [2, 13]. This is particularly counter-productive in the energy sector where the broad goal of achieving sustainability is often uniform across competing companies, and the impact can be maximised from collaboration while retaining or improving profits if correctly facilitated [2]. Global bodies should consider this and come to appropriate agreements on patent recognition and idea sharing in order to maximise the impact of innovations to address the energy challenge.

A key shortcoming of this framework, however, was that although it may be inherent in some of the above statistics, it omits the important but hard to quantify influence of government regulation. This can be a critical factor in accelerating or impeding the adoption of new ideas [7], and is

an aspect that international forums should aim to address in discussions.

*A. Frugal Innovation*

Approaches to innovation, however, naturally differ between developed and developing countries [2]. Although the broader goals are aligned, there are several factors such as localised priorities and access to both technology and funding which are vastly disparate. While innovation is currently considered a large expense to most of the developed world, frugal innovation, also known as 'inclusive' innovation, is becoming an increasingly prevalent term in business by questioning whether significant innovation requires equally significant funding. Frugal innovations are most commonly emerging from the populated areas of India and China where a large class of less wealthy individuals is matched with a thriving economy [14]. Here, the shift to a technologically advanced economy and the desire to improve citizens' quality of life naturally sees frugal innovators drawn to the energy industry [14].

Numerous successful examples, such as a $70 battery-run small fridge [15] and a water purifier utilising rice husks [16], have demonstrated that frugal innovation can overcome low profit margins with large volumes and demand. Ignoring the lower portion of the socio-economic pyramid in such booming and transitioning economies is clearly a poor strategic decision [17]. Additionally, in many cases frugal innovations have found surprisingly high demand in the developed world where a natural resource crunch is coupled with the push for a more resilient and sustainable post global financial crisis economy. This has also seen frugal innovators profit from the income inequality in their own countries as even the wealthy look for more economical solutions, making the case for the universality of frugal innovation. The developed world has as much to gain from the processes of frugal innovators in low-income developing countries, as it has to offer in terms of cutting edge technology and investment. This further enhances the value proposition of global innovation alliances to all tiers of our local and international community.

Establishing successful global innovation alliances between developed and developing countries is the most efficient way to maximise the environmental impact of new technologies or processes [2]. If the structure of these alliances is optimised, these can also serve to enhance the return on innovation investment for both participating parties. Global summits are ideal forums to develop initiatives and commitments that address this economic and environmental issue by fostering collaboration.

To further validate the research above, a number of successful and mutually beneficial global innovation alliances were examined. A selection of these are discussed below in order to highlight the potential role of international forums in fostering further collaboration.

## III. Case Studies: Global Innovation Alliances

*A. Case study one: Clean Development Mechanism (CDM)*

The CDM is an ideal example to examine as it demonstrates a process, rather than product innovation, which represents an ideal model for alliances initiated by global leaders. It revolutionised the management of carbon offset credits in a way that was mutually beneficial to both developed and developing countries.

The CDM was part of the first commitment period of the Kyoto Protocol and enabled a developed country with emission offset commitments to invest in emission reduction projects in developing countries in exchange for certified emission reduction (CER) credits [18, 19]. There were over 5000 registered CDM projects during this period [18], which involved initiatives including the installation of solar panels, hydro power stations and biofuel production resources into under-developed communities [18, 20].

The CDM was effective in providing a financially and environmentally sound platform for collaboration in the energy sector [19]. During the eight years of this Protocol period, the mechanism mitigated the equivalent of over one billion tonnes, the equivalent of removing 180 million cars from the road [18]. With CDM projects on average being 15-50% less capital intensive and with compliance savings of US$3.6 billion over 4 years, this solution was clearly economically justified for participating developed countries. Developing countries also realised clear benefits, with CDM projects representing half of the new investment into renewable energy in developing countries in 2011 [18]. Studies have also shown that increased energy access, one of the aims of the CDM, has had positive flow on effects in the education and health sectors [20]. These initiatives have also served to reduce communities' dependence on government services, freeing up these valuable resources. Less quantifiable benefits of the mechanism include the increased transfer of technology and knowledge sharing between developed and developing countries as well as raising community awareness of environment issues [20].

With 161 countries involved [18], the CDM initiative effectively acknowledged that the energy challenge facing our International community logically required a global rather than local solution. It therefore worked to stimulate sustainable development whilst encouraging environmentally responsible business. It proved that successful global solutions are possible, which should serve to motivate global bodies towards negotiating a unified position on similar current challenges. This was a successful demonstration that governments have the capability and resources to foster product innovation via the development of their own innovative, cost effective global process solutions.

*B. Case study two: Suzlon*

Suzlon's rise to success in the renewable energy sector involved a number of strategic global innovation alliances. Suzlon is an Indian wind turbine manufacturer and wind power solutions provider, founded in 1995 and now operating across 17 countries in 6 continents with International investors and subsidiaries [21]. The first of it's global alliances was in 1995 when Suzlon engaged in an arrangement with Südwind in Germany [21]. At this stage, Suzlon was looking to gain technical expertise, so experience was the most valuable factor to the company. They therefore structured a technical collaboration arrangement to facilitate this learning [22]. After gaining a fundamental level of technical understanding, Suzlon entered an adjusted agreement with the new owners of the German company. This involved Südwind continuing to share knowledge related to technical experience, but now receiving royalties on Suzlon's wind turbine sales [22]. This 5-year agreement saw Südwind now capitalizing on the understanding of demographics and market experience in India that Suzlon could now provide once equipped with the aforementioned technical expertise.

Following this, with the confidence of a greater level of experience, Suzlon entered into a licensing agreement and a one-time fee agreement with two specialized overseas manufacturing firms [21, 22]. They viewed this arrangement as an efficient model for global technology transfer, which is a construct that should be a high priority for global bodies. This again questions the role of intellectual property laws in limiting innovation. By essentially acquiring technology and experience from second-tier overseas firms, Suzlon fast-tracked their path to innovative manufacturing in a cost effective manner [22]. The shift in the dynamics of these joint-manufacturing ventures compared to the previous knowledge sharing was reflective of Suzlon's growing confidence and capacity to handle increased risk. Global bodies could maximize the mutual benefit of similar innovations by developing policies to support these international alliances in the energy sector.

Suzlon's choice of alliance models were closely matched to their manufacturing and innovation strategy which aimed to increase internal R&D and production [22]. To grow and develop this capacity, Suzlon founded R&D centres in strategically selected learning networks [21]. Concurrently, Suzlon focused on forming a number of subsidiaries and alliances around the world [21]. These ranged from highly focused agreements such as the innovative design of a small component with an Austrian-owned company through to broad R&D knowledge sharing with a blade design firm in the Netherlands [21]. Suzlon recognized the value of these successful global alliances leading to significant innovation breakthroughs and consequently decided to establish global headquarters in Denmark, a leader in the international wind turbine industry [21]. These investments into developed overseas economies strengthen the argument for global bodies representing advanced nations to form alliances with those from low-income developing countries.

One defining factor of Suzlon's success was the decision to continuously expand the overseas arm of the business, rather than just focusing domestically [22]. The long term vision of the company combined with the culture of continuously learning meant that Suzlon decided to invest in overseas alliances regardless of the fact that Suzlon had not yet gained significant market share in India [21]. In a number of cases, Suzlon capitalised on the technological understanding gained through its global alliances by eventually purchasing majority control or entirely acquiring the overseas partner companies such as Hansen, which manufactures gearboxes [22]. An additional advantage here is the byproduct of acquiring a significant number of skilled personnel around the world, adding significantly to their value.

Despite their global outlook, Suzlon was also continuously committed to improving the socio-economic situation for the local Indian demographic. Their Corporate Social Responsibility (CSR) has therefore allowed them to cover over 1000 villages, benefitting over 140 000 families. [21] They now claim over 40% of the cumulative market share in India [21], which is a strong indicator of their local success developed through their strategy of wide global innovation alliances.

The Suzlon case study effectively demonstrates that global innovation alliances can allow a small company in a developing country to accelerate the development of creative energy solutions by utilising the well-established expertise of developed countries, with mutual financial benefit.

*C. Case study three: SunEdison*

In the converse situation of case study two, leading American company SunEdison demonstrated the value of a business in the developed world partnering with companies and government organisations operating in developing countries. In 2015 alone, SunEdison has formed alliances with companies across Africa, India and South America to provide innovative hydro, wind and solar energy solutions. SunEdison Social Innovations is a key arm of the global company that aims to maximise environmental and social impact through business model and product innovations working towards economical renewable energy solutions.

In the first instance, SunEdison has proved that global alliances are highly effective in the creation of successful business model innovations in this sector. It was only through working closely with local communities in developing countries that they understood that funding was not the main concern [23]. Historically, well-funded initiatives that aimed to provide electricity to rural communities have failed due to the short-term outlook of the organisations involved, which often fail to provide replacement parts and necessary

maintenance for newly installed systems [23]. This serves as a significant reminder that the value of local knowledge must not be underestimated when forming these alliances [23, 24]. SunEdison therefore developed business models that consider the full product life cycle and the knowledge of the affected communities when forming and implementing innovations [23].

Another example of business model innovation is SunEdison's creative approach to financing of their various renewable energy solutions. In Nepal, for example, SunEdison used rent-to-own loans over five to seven year terms to provide solar power to rural schools and hospitals [25]. As this is a cheaper alternative than diesel energy and does not have the same uncertainty from price fluctuations, it was a viable economic option for local communities and aims to provide electricity to 7 million people by 2020 [25]. In the case of SunEdison acquiring Energy storage solutions company Imergy, which already had operations in India, SunEdison intends to experiment with different contract and price options including prepaid plans and leasing [26]. SunEdison intends to use Imergy's knowledge on appropriate contract lengths for local telecommunications providers when developing these plans [26] in order to provide solar energy to 20 million people who otherwise would not have access to electricity [27].

SunEdison also acknowledges the value of global alliances for the creation of tangible product technology innovations that allow them to capitalise on largely untapped markets of the developing world. A key example of this is in the development of their Outdoor Micro-station, which demonstrates a deep understanding of the needs of local communities by providing a small off-grid micro power station that can be installed in a few hours, is weatherproof, scalable and requires no maintenance [23]. Demonstrating their understanding of the importance of the aforementioned long-term support, SunEdison provides 24/7 performance monitoring with the power stations [23]. SunEdison also recognises the benefits of encouraging entrepreneurship within the communities and ensures that local staff collaborates with creative locals [23].

In addition to local knowledge, in some cases the developing country has also provided crucial technical skills while SunEdison's value proposition has become more in the project and financial management [23, 24]. This was seen in the Omnigrid Micropower Company partnership to bring electricity to millions across India [23]. Utilising the skills of local residents also provides significant socio-economic benefits, as seen by the predicted creation of 4500 direct jobs and over 15 000 indirect jobs through SunEdison's partnership with local manufacturer Adani to build the largest solar manufacturing facility in India [23].

SunEdison has recognized that there is significant financial opportunities in the energy sector of emerging markets due to the power deficit, economies of scale and the government incentives offered [23, 24]. They believe that the majority of future global electric power infrastructure investments will be deployed in these areas, and have received confirmation of this in the form of backing by JPMorgan Chase Bank, Barclays, Citi and Morgan Stanley on their initiatives in the developing world [23, 24]. SunEdison's ongoing commitment to providing reliable and affordable solutions to progress communities in developing countries has proved to be economically sound as it has secured them significant contracts, such as the 2015 award of five solar projects in Africa based on their track record since entering the market in 2011 [23].

## IV. Discussion: Key lessons

The above case studies serve to prove that innovation alliances in the energy sector have scope for significant mutual benefit. This includes not simply economic advantages, but increased social cohesion and international co-operation including idea sharing and technology transfer. These examples demonstrate the value proposition for a company with roots in a low-income developing country, such as Suzlon, to engage in innovation alliances with the developed world as well as the reverse situation as discussed with reference to SunEdison. The CDM case study validates the role of strategic government alliances to encourage innovation in the Energy sector.

These case studies should therefore serve to highlight the need for action from global bodies on two stages. Firstly, these organisations should advocate that policies be implemented on a local level to support small business and research institutes in entrepreneurial or innovative ventures in the energy sector, particularly with scope for global expansion. This applies to both developed and low-income developing countries. Secondly, innovative strategic government solutions to large scale climate change and energy challenges should be encouraged with an emphasis on agreements between low-income developing countries and the developed world.

It is, however, important to note that there are a variety of often-underestimated social and economic considerations that need to be carefully evaluated in the formation of an innovation alliance in the energy sector. Despite the fact that these collaborations are of vital environmental importance as well as often financially sound decisions as discussed above, they are frequently mismanaged [28]. Even the successful case studies described here needed to overcome significant challenges during their journey. These include difficulties from a political, legal and socio-cultural perspective. It is only by addressing all key factors that true sustainability can be achieved. This is encapsulated in the 'Three Pillars of Sustainability' shown in Figure 2, which highlights the importance of equanimity between the environment, social and economic facets.

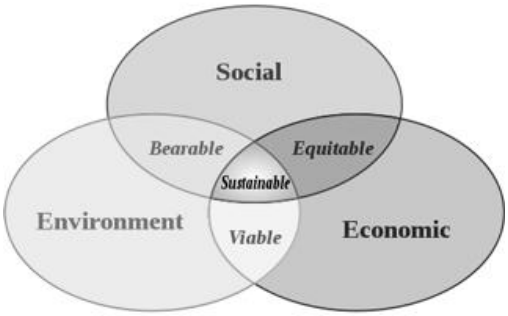


Fig. 2. Interaction of the three pillars of sustainability [29]

Political stability, risk and uncertainty are crucial to consider when considering forming a global alliance in the energy sector [2, 4]. It is vital that the political environment of both parties is independently assessed, as well as examining any barrier or support for interactions between the countries involved. It is commonly argued that Government bureaucracy impedes innovation [30], and trade barriers are an important example of this. These political agreements can serve to hinder or assist the flow of information, goods and services in an alliance. Bureaucracy in low-income developing countries, particularly relating to mandates in the energy sector, is typically less of a barrier to innovation, which adds value to their potential contribution to an alliance [12, 14]. The CDM process faced the challenge of significant criticism for being overly complex and non-transparent [20], which served to slow the approval of proposed projects.

The Government's ability to spark private sector interest in the energy industry further validates the importance of this consideration when choosing a model for global energy alliances. Historically, Government spending in alternative energy has sparked venture capital and corporation investment into innovative renewable energy projects An example of this was the Clean Energy Finance Corporation (CEFC) which was funded by the Australian federal government and served as a minority investor in a number of renewable energy, energy efficiency and low emission technologies [31]. These investments were typically bolstered by private companies and aimed at achieving positive financial return [31].

Additionally, private sector investment is often motivated by Government incentives such as grants and funding available for innovation, broadly and more specifically for energy related projects [3, 32]. Another example of the effectiveness of public-private partnerships could be seen with SunEdison collaborating with the Indian government in the development of sustainable energy solutions to take advantage of incentives [24]. Tax reforms or exemptions for start-ups are fundamental policy decisions that promote a Government's commitment to innovation [3, 7]. Renewable energy targets can provide further evidence of a Government's appetite for change and innovation in this industry. This commitment to sustainability and innovation from the political decision makers of all participating countries needs to be carefully evaluated when combining different political environments. Global bodies can therefore serve to drive consistency in energy policy and thus ease the process of initiating mutually beneficial global innovation alliances in this industry. By agreeing on common goals, energy innovation processes would be streamlined and collaboration would be optimised.

Differing regulations across nations can create significant challenges in developing mutually successful innovations. This is particularly true in the energy sector, which is typically more highly regulated in developed countries [2]. An absence of internationally accepted regulations can also discourage or discount innovation alliances. This was evident in the CDM where the lack of sustainability standards likely caused a bias towards cost-efficient rather than highly sustainable development projects [20, 33].

The common perception is that the demographics of both sides of an innovation alliance should be closely matched, however, in many cases there is equal if not greater value in complementary populations [13]. Key demographics to consider include labour force, average income, urbanisation, energy usage, access to electricity and proportion of energy used from renewable sources. A challenge, however, is to ensure that technology research is ahead of the most advanced participant but still includes the least advanced. Suzlon chose to overcome this challenge by establishing global headquarters in Denmark, a leader in the international wind turbine industry [21], to ensure that it was included in the cutting-edge research.

Experience is a factor that commonly has the most distinct disparities between the participating parties. This can be surprisingly advantageous, as frequently complementary core competencies are the key to successful alliances [13, 28]. SunEdison is well-known for leveraging different experience-based strengths following acquisitions to maximise impact and profitability [23, 26]. These incongruences can be the catalyst to push established firms from incremental to disruptive innovations to reach new markets [13, 34]. This is part of the value proposition for developed countries to collaborate with frugal energy innovators, whose lack of resources has frequently forced them to develop fundamentally different transferable processes [12, 14-16].

It is vital to recognize different types of experience when evaluating the value of a global innovation alliance, and not over-emphasize only the technical aspects. The importance of commercial experience including sales channels and understanding of the local industry are often underestimated in the energy sector despite the fact that these can significantly impact the success and distribution network of an innovation [35]. The public appetite for innovation and renewable energy

is also essential to consider as it is necessary engage the public for successful commercialization of innovations or policy reforms [2, 36]. Experience with the market, industry and local customers is therefore highly valuable in this context [2, 35]. Many CDM projects have demonstrated the importance of informing stakeholders about climate change issues and their impact for the community [20].

On the basis of the above findings, the following recommendations have been developed. This research proposes that global bodies should:

- Ensure that when changing existing policies, their governments recognise the importance of a stable policy environment in enabling new businesses to commercialise innovations with the assurance of long-term certainty.
- Incentivise innovation in the renewable energy sector by subsidising loans for new businesses or company divisions working on renewable energy, energy efficiency and low emission technologies.
- Collaborate to implement and incentivise programs that link research institutes to industry, with a particular focus on International programs such as global University research groups that include low-income developing countries.
- Encourage the adoption of legislation to support evolving global finance solutions, including crowd-sourced capital and peer-to-peer lending. This should include a review of the bureaucracy involved in small business from incorporation to dissolution and the regulation of non-accredited investors. The aim should be to ensure a balance between investor protection and capital financing. For low-income developing countries, the importance of access to technology to enable these investments should not be underestimated, and the formation of global crowd-funding market alliances should be encouraged.
- Ensure insolvency and bankruptcy laws for under 25's do not unduly penalise entrepreneurial behaviour. This encouragement of youth participation in the economy should be a core responsibility of global bodies and has the potential to play a significant role in addressing youth unemployment.
- Promote collaborations between young entrepreneurs, the public sector and the private sector within the global energy industry by creating initiatives such as innovation hubs, summits and conferences to educate and share ideas in this critical arena.
- Invest in the development of online platforms that encourage global knowledge sharing in areas including innovative energy finance solutions and new low-emission technologies.
- Reduce trade barriers for environmental and energy-related goods and services to encourage increased collaborations in order to maximise sustainable impact.

## V. Conclusion

Global innovation alliances are increasingly critical in the energy sector in order to address the global sustainability and climate change challenges currently facing our international community. Innovation has been proven to be a pivotal key in unlocking solutions to these issues. Despite frequent hesitation to discuss energy and climate change issues at global forums such as the G20, this research makes the case that it is not just an environmental issue - rather, it has profound economic, financial, political and social relevance. The potential of our economies is ultimately limited by our ability to innovate, and this is particularly grave in the time-sensitive energy industry.

International forums have the potential to play a pivotal role in this area through two main arms. The first involves localised policies and incentives to support the positive global innovation initiatives of energy companies such as Suzlon and SunEdison as well as entrepreneurs and start-ups. The second is through the formation of strategic alliances and solutions to large-scale global challenges. This includes programs similar to the CDM as well as addressing issues such as trade barriers. Future process based innovation should continue to focus on financing solutions for the energy sector such as crowd-funding. The developing world crowdfunding potential has been valued at 1.8 times the global venture capital investments at US$93 billion [37], and therefore should not be underestimated in it's role as an innovative and inclusive global solution.

It is, however, necessary to identify an optimal, mutually beneficial model for any global innovation alliance between low-income developing countries and the developed world. If correctly managed, these have had demonstrated success in maximising both the financial return and impact of innovations in the energy sector. The opportunity to gain from prospects in emerging markets and accelerate technological developments is significant.

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