

# An Analysis of Economic Challenges of Fuel Cell Commercialization

Atul Dadhich

**ABSTRACT:** Financial development should depend on more harmless to the ecosystem and proficient creation processes as asset shortage, outrageous environmental change, and contamination levels rise. As a result of their high effectiveness and harmless to the ecosystem activity, energy components are an optimal option in contrast to interior ignition (IC) motors and boilers on the way to greener enterprises. Be that as it may, as another energy innovation, power devices presently can't seem to accomplish critical market infiltration. We use life cycle and worth chain exercises to direct a techno-financial and ecological investigation of energy component frameworks in this examination. In the first place, we investigate the course of energy component improvement and figure out which exercises ought to be completed in light of the power module life cycle, esteem chain, and end-client acknowledgment standards. Following that, we present a solidified comprehension of the institutional obstructions to energy component commercialization. To acquire an upper hand, an energy component should outflank its rivals, like IC motors and batteries, on the essential end-client acknowledgment standards of capacity, cost, and unwavering quality. Energy component fix and support costs (because of their low unwavering quality) can bring about tremendous expense increments and diminished accessibility, the two of which are significant variables in end-client acknowledgment. The energy component industry should sort out some way to get through this unwavering quality obstruction. This paper dives further into our work on the fundamental obstructions to energy component commercialization throughout the long term, as well as the power module's expected significant job in a future low-carbon green economy.

**KEYWORDS:** Energy, Environment, Fossil, Fuel, Renewable.

## I. INTRODUCTION

Financial growth as the total populace develops and petroleum derivative energy supplies decrease, the world's energy supply might be inadequate to fulfil rising needs or meet long haul ecological objectives.

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Atul Dadhich, Assistant Professor, Department of Electrical Engineering, Vivekananda Global University, Jaipur, India (Email Id- dadhich.atul@vgu.ac.in)

Subsequently, numerous nations are progressively worried about future energy security and ecological maintainability. The International Energy Agency characterizes energy security as "the persistent accessibility of fuel sources at a reasonable value" (IEA). Numerous nations have put forth long haul attempts to foster a low-carbon economy and green enterprises to guarantee an energy supply that is viable with their financial turn of events and ecological destinations. There are two ways to deal with accomplishing a low-carbon economy: one is to expand the portion of environmentally friendly power energy to fulfill rising energy needs while diminishing petroleum derivative reliance, along these lines decreasing ozone depleting substance (GHG) discharges; the other is to save energy and lessen emanations by working on the effectiveness of existing energy frameworks. Environmentally friendly power's critical turn of events and reconciliation can prompt a low-carbon green economy and new business potential open doors[1]–[4].

Wind energy, sunlight based energy, bioenergy, and flowing energy are only a couple of the inexhaustible assets that have been created. While each sort of environmentally friendly power has its own arrangement of advantages and disadvantages, consolidating them with existing petroleum derivative frameworks convolutes energy the executives and makes it harder for state run administrations to coordinate approach and speculation. Subsequently, investigating a solitary sort of energy framework is at this point not adequate to appreciate a country's general energy security needs and future energy heading; all things being equal, a deliberate and thorough comprehension of a more extensive scope of energy accessibility and variety is required. Non-renewable energy sources, like petrol, flammable gas, and coal, keep on overwhelming in many nations. For instance, as indicated by the US Energy Information Administration (EIA), petroleum derivatives represented 79.78 percent of complete energy utilization in the US in 2011. Subsequently, there is a great deal of space for energy preservation and discharge decrease, which can be cultivated by expanding the energy effectiveness of existing energy frameworks. Power devices can be an optimal option in contrast to existing nuclear power frameworks because of their high warm effectiveness in changing over energy, which can be twofold that of conventional motors. Subsequently, power device innovation can assist with giving environmentally friendly power while additionally saving energy and bringing down discharges in conventional frameworks [1].

Numerous contemplations should be made when energy components go from model to business organization to ensure a satisfactory capital return and a net positive life cycle assessment. Without government appropriations, be that as it may, an adequate capital return has not been accomplished. We inspected and resolved these central points of contention of energy component increasing in our series of articles. The confounding, "chicken versus egg" issues of hydrogen fuel, an absence of hydrogen foundation, and energy component market infiltration were completely clarified. Energy component innovation isn't hampered by an absence of hydrogen foundation. For the energy component advertises, the misrepresentation around foundation is underhanded. Be that as it may, for end-client reception of energy components, the innovation's trustworthiness might be a higher priority than its sturdiness. It, then again, stands out enough to be noticed[5]–[9].

We investigated energy component increasing issues and introduced power module increasing standards and hypothesis. To improve energy component stream fields, the destinations and standards of stream field plans were recommended. We additionally proposed an incorporated methodology to tending to the increasing issues with energy components. The essential objective of this article, which is important for a progression of studies on energy component increasing, is to analyze the techno financial challenges of power device commercialization by means of brought together learning of institutional obstructions. We'll take a gander at part life cycles and worth chains, as well as assembling and get together cycles, as well as end-use enterprises. This will prompt a more noteworthy information on these issues, permitting state run administrations to settle on more educated choices concerning how to make low-carbon economies and innovation by advancing asset effectiveness and harmless to the ecosystem energy. The auxiliary objective is to see how energy components could assume a part in future low-carbon economies and how they may add to a greener assembling area[10].

#### **A. Potential role of fuel cells in a low-carbon economy**

The essential parts of this traditional economy are non-renewable energy sources, interior combustion (IC) motors and boilers, and end-clients. Each sort of environmentally friendly power, as an elective energy source, should play out similar undertakings and proposition a similar degree of trustworthiness as the current petroleum derivative model. Energy components might assume a basic part in low-carbon innovation and financial matters in two ways. In the first place, in an environmentally friendly power production network, energy components might be used as an original energy stockpiling innovation. Second, for energy saving and contamination decrease, power devices might be used as an exceptionally productive motor innovation to supplant traditional IC motors, turbines, or boilers. Be that as it may, there have been not many investigations on the significance of power devices and other environmentally friendly power energy sources in the general low-carbon economy[11].

##### **a. Fuel cells and rechargeable battery packs**

The development of renewable energy is a critical component in developing low-carbon advancements for

green enterprises. In the environmentally friendly power industry chain, wind, sunlight based, and flowing energy are the fundamental generators of force. This energy might be used for an assortment of purposes, including running vehicles and warming homes. Environmentally friendly power, then again, is frequently impacted by the season, climate, or topographical conditions, and its transient and geological disseminations are exceptionally different. The assortment of environmentally friendly power assets requires energy stockpiling as well as complex organizations for energy conveyance. Power stockpiling on a major scale, then again, has for quite some time been an issue. Numerous advancements, for example, siphoned capacity hydroelectricity, stage change materials, battery-powered batteries, and energy components, have been created to take care of the issue of energy stockpiling[12]–[14].

Since enormous scope energy stockpiling is expected for environmentally friendly power to be attainable as a substitute for petroleum derivatives, battery innovation and electrolysis-related energy components are two of the most encouraging techniques for huge scope energy stockpiling. Li-particle and Ni-Mn batteries are two sorts of battery-powered batteries that have been made. The simplicity of putting away energy is one of the significant advantages of battery-powered battery innovation. The expense per kilowatthour of force from the framework might be modest, and energy can be delivered in far off places. As an outcome, battery advancements are broadly used in an assortment of light-obligation power sources, including uninterruptible power supplies (UPS), cell phones, and PCs. Be that as it may, batteries have various disadvantages for uncompromising or enormous scope applications, including extensive re-energize periods, more unfortunate energy thickness than elective powers (e.g., methane or hydrogen), maturing, ecological impacts, and more noteworthy assembling costs. These disadvantages of battery-powered batteries might be significant in auto applications also [15].

Battery charging at 240 V with variable amperage may take many hours, depending on the size of the battery. A 120 kW supercharger could require 30 minutes to accomplish a practically identical measure of charge. Power devices that utilization energy-thick energizes (like hydrogen or methanol) then again, offer a conspicuous advantage as far as staying away from the issue of re-energizing time and reach. An energy component vehicle (FCV) may refuel with sufficient hydrogen to travel 200-300 miles (1 mi = 1.61 km) in 3-5 minutes. The US DRIVE Fuel Cell Tech Team has set an objective for a FCV: it ought to have the option to run for 8000 hours or more (around 150 000 miles). Under run of the mill conditions, a standard lead-corrosive battery has a normal lifetime of four years accepting it is completely energized and not presented to serious temperatures. Because of spilling and maturing, batteries should be supplanted at regular intervals, regardless of whether they are not being used. Energy component disintegration, then again, is reliant upon activity hours. Moreover, the expense of a battery pack rises quickly as the limit of the battery develops, and the battery cost is significantly more noteworthy than the expense of a comparative limit energy component[16][17]. Subsequently, battery-controlled vehicles, like forklifts and cruisers, are broadly used for brief distances and light-

obligation activities, however they are confined for significant distance travel or uncompromising tasks. There have been numerous half and half vehicles (HVs) made. A HV is based on consolidating the powertrain frameworks of a motor and a battery into a solitary vehicle [18]. This might be an energy component with a battery pack or a half and half powertrain with a gas powered motor and a battery pack. While the current objective of an IC motor with a battery pack is to decrease the ecological impact of IC motor vehicles, the objective of half and half energy component electric vehicles (FCEVs) is to consolidate the advantages of both a FCV and an electric vehicle (EV). An energy component powertrain with a battery electric scope of 30-50 miles is utilized in module FCEVs. Utilizing half and half power, such a HV takes into consideration an extraordinary reach and speedy re-energizing. Subsequently, its driving reach might be more noteworthy than that of traditional vehicles while keeping away from the reach and topping off time limitations that EVs face. Toyota, for instance, said that their HVs might have a scope of as much as 1035 kilometers. The battery can keep on running regardless of whether the energy component comes up short, working on the HV's trustworthiness. The expense is more noteworthy than a solitary powertrain framework since there are two arrangements of force frameworks in a single vehicle. Moreover, attributable to the two arrangements of force frameworks, the control arrangement of FCEVs is more confounded [19].

It should be accentuated that, without government appropriations, both battery and energy component costs should be on a way to make EVs and FCVs as modest as IC motor vehicles in many countries by 2022. Since most EV and FCV producers try not to uncover the expense of energy components exhaustively, there is a great deal of guess and conversation about it. Ongoing investigations have shown that electric vehicles (EVs) sponsored by the public authority are inadequate to diminish GHG discharges in Canada and the United States. Government appropriations for electric vehicle buys little affect GHG emanations and are significantly more exorbitant than other motivating force plans. While it is difficult to expect future turns of events, power device innovation is an astonishing and promising method for overcoming any barrier between the diminishing of petroleum derivative use and the development of environmentally friendly power. This is on the grounds that to the high transformation effectiveness and low discharges of energy components. Subsequently, on the off chance that the new financial mode involving power devices as an elective IC energy source is compelling[8], [20]–[22].

#### ***b. Alternatives to conventional engines***

Most of IC motors are poor in changing over energy. As a general rule, the warm effectiveness of an IC motor is around 20% all things considered. Regardless of whether it expands effectiveness by 1% to 2%, further improvement of IC motors or gas turbine innovation is testing. Every once in a while, a most extreme warm effectiveness of around 38% is attainable, but such a framework is confounded, and costs ascend because of related frameworks like consolidated hotness and power (CHP), which requires the utilization of new advancements.

Energy components, as a sort of high-effectiveness motor, may accomplish above half productivity. Since energy components might be two times as proficient as gas powered motors and boilers, emanations may be sliced down the middle on the off chance that they were utilized rather than traditional motors. On account of its more noteworthy effectiveness, the utilization of energy components brings about diminished running expenses for a similar power producing limit. Moreover, energy components are alright for the climate.

They are a magnificent option in contrast to gas powered motors, turbines, and boilers for moderating energy and bringing down contaminations. Moreover, different energizes are utilized by various types of energy components. For instance, gaseous petrol is utilized in strong oxide energy components (SOFCs), ethanol is utilized in direct ethanol power modules (DEFCs), and hydrogen is utilized in proton trade layer energy components (PEMFCs). Subsequently, no significant changes to the current fuel-supply foundation are required. On the off chance that energy components were used to supplant conventional energy frameworks in the reinforcement power, material taking care of, batteries, and CHP areas, the reception of such an exceptionally proficient and harmless to the ecosystem innovation may fundamentally expand the market for power delivering motors and lay out another business mode. On the off chance that an innovative leap forward in power module increasing is cultivated, another spotless energy transformation might arise[6].

#### ***B. Fuel cell technical challenges***

Energy component accessibility is affected by their unwavering quality and sturdiness. This is a significant component in acquiring end-client agreeableness. For end-client agreeableness, the energy component industry will require trustworthy innovation to create and increment working resistance. Be that as it may, there is a critical hole between ebb and flow energy component examination and end-client needs[23].

##### ***a. Reliability for end-user acceptance***

Usefulness, cost, execution (i.e., effectiveness and trustworthiness), and ecological impacts are for the most part factors that impact end-client agreeableness. An energy component with an engine plays out similar undertakings as an IC motor. Energy components are low-commotion and environmentally harmless; the fundamental issue with power devices is execution, which incorporates effectiveness and trustworthiness. The previous isn't an issue since energy components have a significantly more noteworthy effectiveness than gas powered motors. Subsequently, notwithstanding unexpected fix and support expenses, the greatest conceivable specialized obstacle to end-client reception is trustworthiness.

##### ***b. Technology readiness levels***

To direct the assessment, a restrained technique that empowers repeatability, consistency, and routineness should be utilized, with monotonous stages and standards. Innovation availability levels (TRLs) are an ordinarily

involved measurement for deciding an innovation's development level. Subsequently, the TRL of energy component advancement is a proportion of how prepared power devices are proportional up as far as sturdiness and trustworthiness. This assessment makes a common information on the condition of innovation all through the entire advancement chain. TRLs are partitioned into 10 classifications, with TRL 0 being the most reduced and TRL 9 being the most noteworthy. Future and arising advancements are delegated TRLs 1 and 2, modern improvement projects are named TRLs 3 through 8, and commercialization is named TRL 9. The TRL of energy components is as hard to evaluate as the TRL of a refined substance handling plant. Energy components, in contrast to different merchandise, don't have a characterized TRL. Energy component items are accessible at all TRLs, from TRL 1 (fundamental examination) through TRL 8 (business frameworks), with TRL 9 being the most progressive (fuel business organization). Notwithstanding the way that amount fundamental examination has been done on conjectured ideas, for example, the impetus and multiphase stream in a channel, energy component gadgets have been conveyed consistently[24].

### c. *Technical barriers to reliability*

The cost of support and fixes because of unexpected issues might be critical. Under similar conditions, the directs in a cell and the cells in a stack framework should be operationalized. The structure and increasing methodology should be completely investigated as far as the activity and dangers associated with the energy components and frameworks used in the increasing, which are basic in deciding the power module advancements' reception. To conquer the significant expense and restricted accessibility of energy components, trustworthiness issues should be settled. Keeping all channels and cells working at a similar level is exceptionally difficult. The increasing speculation has shown that accomplishing a totally uniform stream appropriation stays a trouble. A minuscule, lopsided stream dissemination might cause functional misalignment of cells and stacks, bringing about expanded vulnerability and lower effectiveness. As an outcome, successive fix and support personal time might impact the significant expense of energy components, giving the presence of helpless trustworthiness. Microreactor increasing, which uses a comparative measured quality, has practically identical issues, as indicated by Powell. The synthetic business' reception of "increase by number-up" as a designing technique is loaded with vulnerability. This is on the grounds that it indistinct outcomes from a wasteful stream dissemination plan in the pilot's plan, demonstrating, and activity. Be that as it may, utilizing the hypothesis of low appropriation to painstakingly plan the stream field, we can handle the non-consistency of an energy component stack in a little reach or inside assembling resilience's.

## II. DISCUSSION

Power modules (FCs) are electrochemical gadgets that change a fuel's synthetic energy into power and hotness (ordinarily hydrogen, yet additionally hydrocarbons and alcohols). Positive highlights like as high effectiveness, low contamination emanations, and insignificant support needs have started a great deal of interest in this innovation in ongoing many years, with R&D on different FC sorts

and applications occurring all around the globe. Following an outline of the innovation's fundamental attributes and key advancement regions, this paper focuses on the two sorts of energy components that as of now overwhelm the market and exploration: polymer electrolyte layer FCs and strong oxide FCs. The parts that follow portray the current status of these innovations, as well as specialized objectives for future progressions, as well as existing and possible applications.

## III. CONCLUSION

Numerous countries have attempted long haul endeavours to make low-carbon economies and green areas to ensure a protected energy supply that is viable with their financial development and ecological objectives. To foster a low-carbon green economy, there are two choices: first, increment the portion of new and environmentally friendly power to satisfy rising energy needs, alleviate GHG discharges, and decrease petroleum derivative reliance; and second, moderate energy and diminish emanations by working on the effectiveness of existing energy frameworks. In the two cases, energy components might be exceptionally valuable. Power modules, as an exceptionally proficient energy-transformation and environmentally well-disposed innovation, may expand warm effectiveness by 5%-40% when used to supplant IC motors and boilers. Energy components might be the best substitution to IC motors and boilers, as indicated by the discoveries of this review; power devices may along these lines add to a low-carbon green economy, and surprisingly a green modern transformation. Be that as it may, energy components have neglected to acquire significant market infiltration. Utilizing a day to day existence cycle investigation and worth chain, we directed a techno economic and ecological investigation of energy component frameworks in this article. Albeit the current expense of energy component creation is as yet more noteworthy than that of IC motors, it was found that due of its better warm effectiveness, its functional expenses might be significantly lower than those of its adversaries (e.g., IC motors or boilers). Moreover, fabricating costs are not a critical issue in end-client agreeableness or energy component reception. Be that as it may, attributable to its helpless trustworthiness, energy components' unexpected fix and support costs might bring about a tremendous expense increment of up to 60%, as well as a decrease in power device accessibility. Subsequently, expanded support and fix costs, as well as diminished accessibility, are the main obstructions to end-client agreeableness and energy component commercialization. The energy component industry has the issue of conquering innovative trustworthiness and sturdiness restrictions.

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