

# Frugal Production and Low Cost Strategy —The Case of Nissan’s Electric Vehicles—

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## Abstract

*High costs, the unavailability of fuel, environmental problems, greenhouse gas (GHG) emissions and air pollution in urban areas are some of the driving forces for international organizations and automobile manufacturers. Due to the above mentioned issues - electric drive vehicles (EDVs) are set to make significant progress with advantage in new technologies, innovation, and new products. Recently, the electric vehicles (EV) market has shown steady growth globally and the automotive manufacturer Nissan has innovated new technology offering more comfort and lower cost vehicles in order to keep up with the demand from the growing market.*

*This paper will analyze possibility of EVs through frugal production practices and provide an overview of the factors that can bring about the high component costs of EVs, which depend on a production and at high production volumes. This study will also look at frugal production strategy and the cost reduction strategies of the Nissan automobile company.*

**Key Words:** Electric Vehicles, frugal production, technology, low cost strategies.

## 1. Introduction

Electric vehicles (EVs), are not something new to the modern world. But with the technological innovation and increasing concerns about air pollution, global warming, and the reduction in quality of life in urban areas. These above problems are starting an environmental consciousness amongst consumers. Arguably some if not many governments of the world are taking action to reduce greenhouse gas (GHG) emissions from their transport sectors. The drive an electric drive vehicles (EDVs) in transportation sector widespread and reduce oil consumption, and GHG emissions. However, before discussion more in context of EDVs, it will find-out the types of EDVs in Japan. EDVs or and next generation vehicles (NGVs) which are hybrid electric vehicles (HEVs), plug-in hybrid (PHEVs) electric vehicles (EVs), and fuel cell electric vehicles (FCEVs) clean energy vehicles. HEVs), PHEVs, and EVs are on roads throughout Japan. Of the types mentioned above EVs, in particular battery electric vehicles (BEVs) like the Nissan Leaf and Chevrolet Bolt, the PHEVs, and HEVs, (Toyota Prius Prime and Ford Fusion Energy), are expanding their market share in Japan as well as in the world.

Governments in both developed and developing countries have been encouraging the adoption of EDVs and electric mobility through several incentives. Nonetheless, several crucial issues need to be addressed in order to bring down the cost of EVs even further. EVs are more expensive than gasoline vehicles due to the high cost of batteries, but buyers are eligible for various government purchase incentives, subsidies, tax cuts, credit and other exemptions. Automobile companies worldwide, including Nissan, Toyota, Honda, Mitsubishi, BMW, Tesla, BYD, Daimler, Hyundai, Ford, and Volkswagen are making efforts to make products at as low a cost as possible for affordable markets.

Under these circumstances it will be analyzed the possibility of low-cost strategies of EVs, through frugal production strategy within Nissan. Frugal production strategy contributes to low cost business strategy strategies that is, 'doing more with less' or 'process more with less' which contributes to lower resource, production and market costs which will make Nissan's EVs more affordable.

This article provides an overview of EV research, examines the frugal production strategy that can reduce vehicle component costs and the operating costs of advanced technology. This study is based on secondary and archival materials and documentation. The discussion is organized as follows: Section Two, Frugal Production Strategy; Section Three, Nissan's Electric Vehicles; Section Four, Analysis of Nissan's Frugal Production Strategy; and finally Concluding Remarks.

## 2. Frugal Production Strategy

Frugal production strategy provides functional solutions through avoiding unnecessary materials is the same as using fewer resources frugal engineering. George *et al* (2012, 1) defined frugal innovation as 'innovative, low-cost and high-quality products and business models originating in developing countries and exportable to other developing countries or even the developed world'. Frugal production is a process, which aims at lowering costs, service rendered without affecting a products quality by using new and improved methods and techniques. Frugal production is becoming popular due to squeeze costs and no frills structure. Through frugal production methods of substitution are ascertained to reduce the production materials. It ensures savings in per unit cost and maximization of profits for an organization.

Frugal production strategy is essential for developing and developed markets, where consumers are more concerned about high cost issues. Frugal production strategy could be successfully adopted, if managers could use the basis of 'doing more with less' to differentiate themselves from competitors. From the author's previous research, Chowdhury (2019c), "Frugal Innovation Strategies of Electric Vehicles: A New Era" published in the University of Kitakyushu's *Journal of Law and Political Science*, Vol. XLVII, No. 1/2 in 2019, the term 'frugal innovation' is a combination of the Japanese word 'setsuyaku' and 'frugal engineering', and was coined by Renault-Nissan former CEO Carlos Ghosn<sup>1)</sup> in 2006. He also added

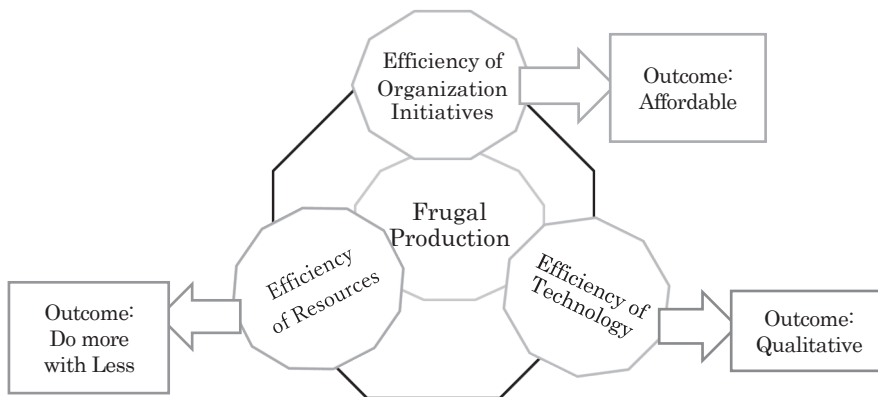
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1) As Carlos Ghosn, a Brazilian-born French national of Lebanese descent, stepped down as CEO of Nissan on 1

frugal ability to cost-effectiveness and severe resource constraints. In essence, adopting an old phrase of Benjamin Franklin's<sup>2)</sup> for the modern age, 'doing more with less' means to 'Waste neither time nor money, but make the best use of both'. Prabhu & Gupta stated that the frugal aspect involves solving problems without being stymied by affordability, resources, and institutional constraints. Prabhu & Gupta (2014, 3309-3312) argue that three broad innovation heuristics are used for frugal service innovation: (1) combining of existing materials, processes and resources through bricolage, (2) reducing time, materials and human resources, and (3) creating self-service options for users. However, Lazcano (2014, 292-301) believes that a global business continuity program is necessary to foster frugal innovation.

Frugal production strategy is an organization initiative to adopt new technology or frugal engineering which reduces resources, and time to produce goods for affordable markets. Therefore, it is understood to be a re-thinking of products, services, underlying processes and business models so that companies can minimize the use of resources such as energy, capital and time which squeeze costs and expand the affordable customer base, business and profit (Jagati, 2011,1533-1535). The three fundamental goals of frugal production strategy, efficiency of organization initiative, efficiency of technology, and efficiency of resources will be analyzed, and is shown in Figure 1 below.

**Figure 1: The Frugal Cost Strategy**



Source: Compiled from Bhatti *et al.*, 2018, 109.

April 2017, was arrested at Haneda Airport in Tokyo, on 19 November 2018, on allegations of under-reporting his earnings and misuse of company assets. Renault and the French government continued to support him, presuming him innocent until proven guilty. However, Ghosn retired as chairman and CEO of Renault on 24 January 2019. In December 30, 2019, Ghosn escape by flying out of Japan's Osaka airport on a private jet, to Lebanon on New Year's Eve of 2020, (The Japan Times, January 2, 2020).

- 2) Benjamin Franklin was born on January 17, 1706, in Boston. He was a statesman, scientist, diplomat, philosopher, writer, businessman and inventor. Franklin is often referred to as 'America's Renaissance Man' and one of the most versatile and talented men in colonial America and a leading figure in the American struggle for independence. As the first United States Ambassador to France, he exemplified the emerging American nation. He died in Philadelphia on April 17, 1790. Franklin is on the Series 2009, hundred dollar bill. <https://www.biographyonline.net/politicians/american/benjamin-franklin.html>, retrieved on November 20, 2019.

## **2.1. Efficiency of Organization Initiatives**

Frugal production strategy provides new possibilities for firms originating in emerging economies and moving into developed economies. This special mode of frugal production strategy promotes entirely new diffusion patterns, which warrant increasing attention in individual countries' industrial sectors as well as the managerial implications for each.

Frugal production strategy requires efficient organizational initiative. To achieve success, the frugal production company should evaluate all aspects of the products including, customer demand product specialization and function compared to those of their counterparts. Proper evaluation will result in high quality, low cost and a more affordable market. Therefore, organizations should change product design methods and technology. Frugal production strategy needs to find new business models, reconfigure value chains, and redesign products in order to serve 'affordability constrained' customers. It involves challenges that will require change. Ultimately, the goal of frugal production strategy is to provide the essential services customers need, at a price they can afford.

Recently, automakers have been trying to lower costs to a level that the consumer can afford. Although many others company reduce their cost-to performance ratio, the organizations that employ truly innovative operational models are, again, the exception. To design new programs for technical innovation, it is important for stakeholders to understand the market for frugal production globally. There are some companies which adopt a frugal production strategy and raise the quality product and service offerings. Some examples of electrical products are; a \$1,000 electrocardiography machine (ECG machine) of General Electric, a \$100 OLTPC laptop, and a \$12 Nokia solar powered mobile phone but automobile industries offer US\$2,500 Tata Nano car, Renault launched the Logan, at 5,000 euros (today it retails for US\$10,000) and Renault's 'global small car', a US\$5,000 vehicle (Prabhu & Gupta, 2014,3309-3312). These are only some of the low-cost yet high quality products emanating from emerging market opportunities through a phenomenon which is gaining popularity in emerging and developed markets. These products could all be said to have come about through frugal production.

## **2.2. Efficiency of Technology**

Efficiency of technology means innovative solutions that combine high quality products with both low cost and affordability. Efficiency of technology deals with issues in which EV products constitute an unacceptable human harm risk in terms of factors such as occupant safety, electric shock risk, and exposure to unacceptable levels of electromagnetic radiation. Inefficiently designed technology and EVs potentially represent risks to vehicle users in terms of crashes. Battery and engine technology are other factors. There is a risk that EVs will be of highly variable efficiency, resulting in an uncertain environment for consumers. Usually, EVs are charged at (the owner's) home. There is a need to manage the potential risks in this area, which is considered a high priority, due to the potential impacts on the market and consumer should a 'catastrophic' situation arise.

That having been said, EV's are becoming a highly attractive market in developed and emerging economies due to efficient technology solutions connecting high quality with affordability. It is different from the standard innovation approach predominantly practiced in more developed contexts. Frugal production strategy is not only a process strategy but changes for new. The tools and techniques to set frugal goals and priorities need to match a company's production management style and needs. Companies must be willing and able to overhaul every function from R&D to sales and marketing, reorganize the company structure, evaluate human resources policies and incentives, and shift their business model from doing 'more for more or less with less', to 'doing more less and even better with less'. The criteria for frugal production is technical novelty and market novelty. Frugal technology has a higher technical novelty and a higher market novelty than just good-enough and low-cost or affordable.

The EV represents the culmination of numerous technology achievements but there is still a need for more development and innovation within the automobile industry for EVs for a reduction in the overall number of parts, shorter driving distances, longer charging times, and an infrastructure that still needs extensive work done in the area of infrastructure, namely charging stations. In making a vehicle an auto-maker uses 25,000 to 30,000 parts. It is believed, there are many unnecessary parts used in the production of vehicles, contributing to higher costs. The component parts of ICEVs include 30,000 units 100 percent (Table 1) Engine parts of both EV and ICEV are 6,900 units, 23 percent, Drive, transmission, operation parts 5,700 units of 19 percent in ICEV, decrease to 2,100 units of 7 percent, Suspension, braking parts 4,500 units, Body components 4,500 units in ICEV, about 30 percent but EV has no need these parts. Electrical component and parts 3,000 of 10 percent in ICEV, 2,100 parts in EV about 10 percent, other parts 5,400 units uses in ICEV but EV has not need (Chowdhury, 2019c, 13).

**Table 1: Parts Assumption of a Gasoline and an Electric car**

Component of Parts	Component ratio of Gasoline Vehicles(%)	Need of Parts in Gasoline Vehicles	Needless Parts in EVs
Engine parts	23	6,900	6,900
Drive, transmission, operation part	19	5,700	2,100
Suspension, braking part	15	4,500	0
Body component	15	4,500	0
Electrical component and parts	10	3,000	2,100
Other Parts	18	5,400	0
Total	100	30,000	11,100

Source: Ministry of Economy, Trade and Industry (2010), June. Website

An example of a specific component is the EV powertrain, which consists of an electric motor<sup>3)</sup>, an electronic control system, and a single-ratio speed-reduction gear train. The electric motor does not need

3) Three types of motors are being seriously considered: direct-current (DC) commutated (the 'conventional' approach for EVs), alternating-current (AC) induction, and DC-brushless.

a multispeed transmission; it has a more favorable speed torque relationship than an IC engine, and consequently it is easier to cover the entire vehicle speed range with just one gear ratio. The EV's electric drive components, which currently are very costly, could be produced in large quantities at a much more reasonable price. The body must/needs to be modified, both in shape and size, however, the battery storage compartment requires additional parts, this increase would mean an increase the overall vehicle cost.

EV designers are aware that, compared to the 'three-box' (passenger cabin, engine compartment, trunk) IC engine, EVs have a fourth box in the energy storage system. The additional weight of the storage system also has implications for the body design, not only because of the extra load and crash-worthiness requirements, but also in terms of a need for mass reduction (to compensate for the heavy battery<sup>4</sup>). Several options are available to power these accessories in an EV, these options include alternatives that would consume more energy but then further increase the initial vehicle cost.

From an engineering design standpoint, steel provides the required strength and rigidity at reasonable cost, however it is heavy and adds substantially to vehicle mass. Some lightweight materials could easily replace steel in selected non-structural components; with proper design, steel in structural components could also be replaced but because these lightweight materials cost more and require specialized manufacturing techniques, their use would add to the vehicle cost. Thus, lightweight materials' contribution to reduced vehicle energy consumption would have to be evaluated in vehicle cost. Frugal production doesn't mean low tech. On the contrary, highly sophisticated technology can be used in frugal innovation.

### 2.3. Efficiency of Resources

The current 4<sup>th</sup> industrial revolution, is helping to create a more frugal production, one that generates greater value in highly efficient technology, through improved material efficient processes, such as recycling, re-use potential and reducing unnecessary resources. The emphasis on lower cost restricts a designer from using resources such as knowledge, raw materials, personnel and a rule of law conducive to innovations, in excess of that required for frugal-innovation.

In the area of resource management, the Japanese use the sub-concept of just-enough-resources (JER), commonly referred to as just-in-time (JIT or Kanban) for inventory. The idea is to squeeze out three kinds of waste including "*muda*" which represents waste caused by idle resources and unnecessary motions (looking for misplaced tools), "*mura*" which is waste caused by the irregular or inconsistent use of a resource, and "*muri*", which is waste caused by placing excessive demands on resources. In the JER approach, all resources are minimized, including inventory, workers, equipment, job classifications, and product parts and subassemblies, which also seem to frugal production (Chowdhury, 2019d, 157).

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4) According to the METI (Ministry of Economy, Trade and Industry, website) the weight concern an EV is 2.1 tons which battery weight is 550 kg that contributing 26 percent. In general, an EV weighs from 300kg to 600kg heavier than a gasoline vehicle. This means that an EV weighs about 800kg and can travel at between 50km and 90km per hour (METI, website).

As mentioned above, automobile components, right down to the steel used, have steadily become more sophisticated, and often more expensive. The efficiency of resources required, simplifying product components and manufacturing processes into basic elements. In order to re-design both the product and the processes to become more efficient technology and cost effective. The ultimate outcomes of ‘more for less’ are affordable EV consumer fit into market strategies, qualitative products not just about doing more with less. It’s about learning how to innovate under severe resource constraints and turning an opportunity for affordability, accessibility, and growth of production. Frugal production strategy enable new businesses to take advantage of EV producers and customers. Nissan’s EV in Japan will be briefly analyzed next section before the analysis of possibility frugal production strategy in Nissan.

### 3. Nissan’s Electric Vehicle

The automobile industry in Japan has been making efforts to innovate and mass produce EDVs, particularly HVs and EVs. Nissan, Toyota, Honda and Mitsubishi are producing EDVs with the release of the Nissan Leaf, Toyota Prius, Honda Fit, and Mitsubishi i-MiEV respectively. Nissan, stands alone with EV being the ‘first car’, while other manufacturers consider EV as a ‘secondary car’ for limited and specified short-distance driving and daily commuting.

The Nissan car company will now be briefly introduced, followed by an analysis of Nissan EVs. Nissan which was originally named *jidōsha-seizo kabushiki-kaisha* was established in Yokohama City, Kanagawa Prefecture in December 1933. The company’s new name, adopted in June 1934, was an abbreviation for *Nippon Sangyo*, a ‘*zaibatsu*’. Nissan produced its first Datsun<sup>5)</sup> in 1914. After the Second World War, especially from the 1950s to the 1960s, Nissan put emphasis on the development of technology and innovation. In 1952 Nissan made a technology agreement with Britain’s Austin Motor Company. In May 1953, Nissan began selling the first Austin A40 vehicles assembled in Japan and started complete domestic production of the car in May 1956, aiming to become exclusively a manufacturer of luxury cars (Odagiri and Goto, 2007, 41-42). In September 1958, Nissan’s Datsun 1000 won the international car rally in Australia sponsored by Mobil, making it the first Japanese car to win such an event. As a result, Nissan won the Deming Prize for engineering excellence as one of the first Japanese automakers. Toyota and Nissan established their first overseas plants in Brazil and Mexico between 1945 and 1955, and in the late 1950s they followed suit in Chile and South Africa (JAMA, website).

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5) The Datsun brand name from the DAT car which was built in 1914, by the Kaishinsha Motorcar Works (*Kaishin Jidōsha Kōjō*), in the Azabu-Hiroo District in Tokyo. The DAT name was an abbreviation of the three company partners’ family names: *Den Kenjirō*, *Aoyama Rokurō*, *Takeuchi Meitarō*. In 1931, Dat Motorcar Company produced a new small car named ‘Datson’. In 1934, Nissan took control of DAT and the name ‘Datson’ was changed to ‘Datsun’, because ‘son’ also means ‘loss’ in Japanese. But the sun also used to honor every Japanese and is depicted in the national flag – thus the name *Datsun*. (<https://en.wikipedia.org/wiki/Datsun>, retrieved on February 6, 2020).

According to JAMA, Nissan marketed the Nissan President 4000 model in 1965, the largest domestic passenger car, and Toyota followed suit in 1967 with the production of the Toyota Century 3000 model. During the oil crises in the 1970s the fuel-efficient Nissan-made cars 'Sunny' was popular on the U.S. markets. During the 1980s Japanese manufacturers began production in the U.S. and Canada and Nissan established the Nissan Motor Manufacturing Corporation U.S. in Tennessee in 1983 after which Toyota started producing cars at the NUMMI plant in 1984 (JAMA, website). Due to change the name change from Datsun to Nissan in 1981, sales performance dropped in the 1980s and it became the number three automobile manufacturer in Japan, behind Toyota and Honda respectively (Chowdhury, 2019b,65). Nissan overcame many problems to become the second largest automobile manufacturer in Japan and the sixth-largest in the world (5.5 million vehicles) in 2016 and manufactures vehicles globally, and provides products, sales and services in more than 160 countries. It is also the world's largest producer of EVs (Nissan website).

Nissan's first venture into EVs was the Nissan Tama in 1947 which was used until 1950. More than seventy years on Nissan remains at the forefront of innovation in the automotive industry and continues to flourish, with its market share of EVs continuing to rise, making the EV maker one of the 10 most valuable automobile makers in the world. The 2011 Nissan Leaf had a range of just 100 km, but progress in the industry has meant huge leaps towards its newest version of Nissan LEAF, which has a range of 400 km, meaning it can cover a distance of nearly 400 km on a single charge. This is progress that could be intrinsic to the future success of the model, and for the industry. Additionally, the first one pedal driving system has been fitted to the car - an optional system that allows you to transform the accelerator into an e-pedal to function as a start, stop, accelerate and brake pedal. In addition to the latest technology driving steady growth, the company's presence will be further increased through its Nissan Intelligent Mobility.

### **3.1. Nissan Crises**

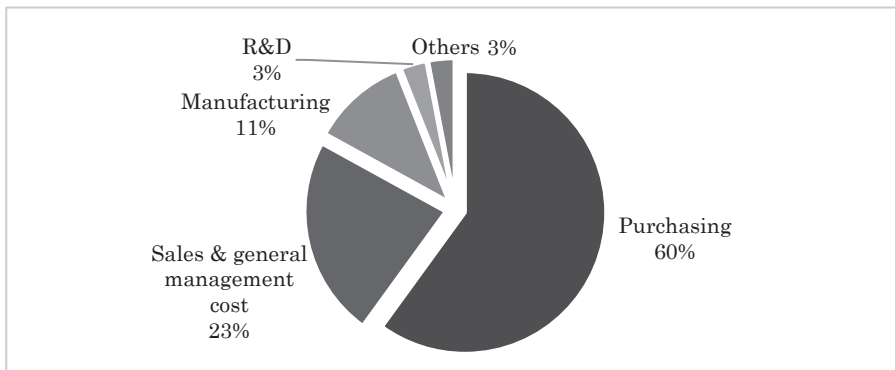
Nissan's faced financial problems due to debts which reached approximately 2 trillion yen (US\$20 billion) brought on by so-called 'strategical mistakes' in the 1990s. To survive, it was essential Nissan had a strong partner for a long-term period in order to regain sustainable growth. With this understanding, L. Schweitzer, Chairman and Chief Executive Officer of Renault in France, and Y. Hanawa, President and Chief Executive Officer of Nissan, signed a partnership agreement in 1999. With this partnership agreement, Renault acquired a 36.8 percent equity stake in the Nissan Motor Company. The strategic alliance between Nissan and Renault has been brought about for the purposes of; joint product development, improved purchasing, quality and manufacturing and to combine complementary firms in order to create a firm of sufficient size to compete on a global basis (Susini, 2004, 241). Carlos Ghosn, joined as its chief operating officer (COO) in 1999, in 2000 was promoted to president, and was appointed Chief Executive Officer (CEO) of Nissan in Japan in 2001. Under Ghosn's leadership, the Nissan-Renault alliance implemented a severe cost cutting and restructuring program, and the Nissan Revival Plan (NRP) led to an



impressive step to overcome the financial crisis it was in. The company has focused on minimizing prices, implemented the NRP and has been successful in reducing costs in activities involving the supply of auto parts. The implementation of the NRP is shown in Figure 2. A one trillion yen cost reduction breaks down 600 billion yen in procurement costs for parts, supplies and tools (60 percent), 280 billion yen in general sales management costs (28 percent), 100 billion yen in direct manufacturing (10 percent), and 20 billion yen from others (2 percent) (Shimokawa, 2012, 117).

There were a number of other international and domestic issues having a negative affect on Nissan-Renault. In 2008 worldwide financial crisis, in 2011, the Great Japan Earthquake and Thai floods in same year. However, Nissan-Renault overcame these crises and more than 5 million units were sold globally. For further sustainable growth, Renault-Nissan-Mitsubishi signed a partnership agreement in 2016, which is the world’s largest automotive partnership. Nissan acquired a 34 percent stake in Mitsubishi Motors. Under the Renault-Nissan-Mitsubishi partnership, Nissan plans to launch 17 EVs models as part of a strategy to achieve annual vehicle sales of 14 million units by 2022, compared with 10.6 million units sold in 2017 (Nissan, website). However, on a negative, Nissan has also been struggling to recover from the ousting of former chairman Carlos Ghosn and the associated financial scandal, because of which the company has seen low profits and strained ties with its French partner Renault.

**Figure 2: Nissan Revival Plan with a cost reduction of one trillion yen**



Source: Shimokawa, 2012, 117.

Another and very recent problem is the coronavirus crisis which started from January in 2020, especially in the epicenter of Wuhan in the Hubei Province in China. The coronavirus has become an pandemic which has and impact will on consumers as well as production in the industry not only in China but also Japan as well as other parts of the world. Toyota, Nissan, Honda and others companies are suspending work at Japanese assembly plants because of disruptions to the supply of automobile parts from China due to the outbreak. The parts shortage has also strained Nissan’s production in southwest Japan, but the company is making temporary adjustments at its plant in Kyushu. The global supply of component parts, including batteries, many of which come from China (The Detroit News, February 10, 2020). This is just

one example of how Nissan and other companies have been negatively affected by the spread of the coronavirus.

### 3.2. Market of Nissan's EVs

There are challenges facing EV production; high costs, limited range of vehicle models, little or no after sale support and long waiting time for spare parts, low performance of the battery technologies, limited mileage range, low vehicle speed and limited payload (Table 2). Battery costs, which account to 25 percent of an EV's price, as for example, the price of battery, in the case of i-MiEV of Mitsubishi Motors is 2,400,000 yen. It more than half of price of electric passenger vehicles is 4,599,000 yen and reduction of this cost is indispensable to the spread of EVs (Chowdhury, 2019a, 39). To overcome these challenges, the development of more reliable and better performing batteries is considered crucial for all types of EVs to become (more) competitive with conventional vehicles. The EVs market mainly is driven by decreasing cost of battery and increasing in popularity among customers. EVs became much cheaper to maintenance than conventional vehicles. In addition to government support also providing incentives on purchase of EVs, and growing fuel prices are the factors of expanded EVs demand. The growth of EVs is attributed to the ever increasing production and sales of automobiles. But unfortunately many people still associate EVs with high prices, have uncertainties about life-span of batteries and a concern that the EV will not be able to fulfill the needs of a regular car user. This makes it hard for the electric vehicle consumer, despite the cars low running cost and potential environmental advantage, to compete with traditional cars when it is time for the family to buy a new car (Chowdhury, 2019c, 17).

**Table 2: Comparison range, battery and charging time of different NGVs**

Vehicles	Range	Battery	Charging time	Vehicle Price (US\$)
Mitsubishi i-MiEV	180 km	16 kWh	Quick charging (50kW) 80% 30 min 8 hours 230 volt 10A	23,845
Nissan Leaf	228 km	24 kWh	Quick charging (50kW) 80% 30 min 8 hours 230 volt 16A	31,545
Toyota Prius PHV	26.4 km in EV mode	4.4 kWh	1.5 hours 230 volt 16A	34,425
Honda Accord PHEV	37.6 km		4 hours 20 min Quick charging 80% 30 min	35,000

Note: The charging time depends on the size of the battery and the output from the socket. The exceptions are the two pure EVs Mitsubishi i-MiEV and Nissan Leaf which support quick charging through the CHAdeMO protocol

Source: Chowdhury, 2019a, 44, 2019 b, 63.

However, Nissan introduced its EV 'Nissan Leaf', in the early 21st century, which was the first EV to be manufactured on a large scale world-wide. This was later shifted to a strategy involving both EVs, HEVs and e-Power vehicles (JAMA, website). The company developed its first battery-powered EV, Nissan Altra, in 1997. In 2009, the EV-11 prototype was based on the Nissan Tiida. Nissan announced the global launch of Nissan LEAF as the first mass-market EV in the world. In 2010 Nissan launched new model EVs in the US and Japan and in 2012 in other markets (Nakata, 2008). As of March 2014, the

Nissan Leaf was the world's best-selling EV excited with 100,000 units sold on global markets, representing a 45 percent market share worldwide and 400,000 units have been sold between 2010 and 2019. In 2018 Nissan Leaf was selling 87,149 units EV and ranked third in the world EDV market (Table 3). Nissan's sales goal is 1 million EVs by March 31, 2023 (JAMA, website, Nissan website).

Nissan has launched attractive new products, Nissan 'Note' e-Power and Serena e-Power which are just two examples of new hybrid technology. The company has also adopted a new product development strategy that will play a major role in the company becoming the zero emission leader in the world auto industry. It sold more than 123,938 Note e-Power models in Japan in its first year 2016, which increased to 131,755 in 2018 (Nissan, 2018).

**Table 3: Top 10 EDV Sales in the World Market in 2018**

2018				2019 (January to November)			
Ranking	Model	Sale	Country	Ranking	Model	Sale	Country
1	Tesla Model 3	145846	USA	1	Tesla Model 3	247011	USA
2	BAIC EC-Series	90637	China	2	BAIC EC-Series	89162	China
3	Nissan Leaf	87149	Japan	3	BYD Yuan S2EV	66405	China
4	Tesla Model S	50045	USA	4	Nissan Leaf	64385	Japan
5	Tesla Model X	49349	USA	5	SAIC	51698	China
6	BYD Qin PHEV	47452	China	6	BMW 500e/le	46651	German
7	JAC IEV E/S	46586	China	7	Mitsubishi PHEV	46431	Japan
8	BYD e5	46251	China	8	Renault Zoe	41901	French
9	Toyota Prius	45686	Japan	9	Hyundai Kona EV	39857	S. Korea
10	Mitsubishi PHEV	41888	Japan	10	BMW i3	37647	German

Source: IEA (2019) Global EV Outlook 2019.

According to the Japan Automobile Dealers Association, in 2016, sales of the Nissan 'Note' were higher than the best-selling Toyota 'Prius'. The popularity of Nissan 'Note', a new model and reasonable price in Japanese market (Kazama, *et. al.*, 2017, 4). Being one of the key players in the industry, Nissan, has already made significant progress in adapting their EV technology to fit consumer needs. The company has the know-how behind it to make it Note the second most popular electric model in retail, and the best-selling all-electric model with over 300,000 units sold worldwide (Table 4).

The U.S. and European automobile makers are producing new model EVs, which is the cause of Nissan's global vehicle sales declining in the U.S., Europe and other global markets, although sales have stayed comparatively high in China as can be seen in Table 4. In China, the EV market is rapidly expanding. Nissan joint venture's EV sales exceeded 20,000 units in 2017, more than three times the previous year. In 2018, the company introduced a top-level version of the new LEAF with longer range and increased power, along with the Sylphy Zero Emission in China. However, it seems to be that EVs are changing Nissan and the whole auto industry worldwide, but batteries are still expensive and there is a lack of charging infrastructure. It is important to improve technology for EV sustainable growth.

**Table 4: Nissan Vehicles Global Production and Retail Sales in Worldwide (Unit: Vehicles)**

	Country/Regions	2016	2017	2018	2019*
Production	Japan	985,541	1,015,033	900,781	523,773
	U.S.	899,483	990,938	820,527	512,174
	Europe	585,848	643,351	504,043	41,790
	China	1,536,615	1,361,030	1,556,527	1,058,970
	Overseas	4,714,967	4,680,741	4,460,107	2,801,616
	Total	5,700,508	5,695,774	5,360,888	3,325,389
	Sales	Japan	557,490	584,053	596,087
	U.S.	1,581,110	1,581,110	1,443,725	875,048
	Europe	756,460	776,435	643,445	345,512
	China	1,541,540	1,370,275	1,571,603	1,034,881
	Overseas	5,206,199	5,084,893	4,926,461	3,005,473
	Total	5,790,252	5,642,383	5,522,548	3,354,381

Note: 2019, data are from April to November,

Source: Nissan Website, <https://www.nissan-global.com/EN/IR/RESULTS/2017/>, retrieved on February 6, 2019.

#### 4. Analysis of Nissan's Frugal Production Strategy

Frugal production strategy for EVs has the advantages not only low-cost but also efficiency technology, reliability and easy maintenance. The strategy focuses on low cost production because it's a strategy that relates tangentially to advancing EV innovation, technology, information technology (IT), artificial intelligence (AI) and digitization. Further efficiency improvements anticipated in the 2018 model, possibly from improved electric motor efficiency and greater used of lightweight materials (Motoring, 2015). Similarly, Renault has made significant efficiency improvements to the Zoe between the 2014 and 2015 models. Renault's greater used of lightweight materials and improved electronic management resulted in a reduction of energy used of approximately 9 percent (Renault, 2015).

Global EV outlook (2018), highlighted the impacts of four key parameters: battery price; car size (affecting the fuel economy and the size of the EV battery); fuel prices and annual mileage (Table 5). It is important to analyze EV cost per mile or km, marginal electricity costs and electricity EV uses per 100 miles or 160 km. Here are comparable figures in kWh per 48.28 km for Nissan Leaf, some popular EVs Tesla Model X, highest kWh per 57.93 km. (Table 5)

**Table 5: Energy Economy of Different Types of EV**

Vehicle Model 2017	Kwh per 100 Miles (160 km)
Nissan Leaf	30 (48.28 Km)
Ford Focus Electric	31 (49.88 Km)
Chevy Bolt	28 (45.06 Km)
BMW i3	27 (43.45 Km)
Tesla Model S	34 (54.71 Km)
Tesla Model X	36 (57.93 Km)
Tesla Model 3	27 (43.45 Km)

Source: <https://www.fueleconomy.gov/feg/Find.do?action=sbsSelect>, retrieved on June 6, 2019.

#### 4.1. Do more with less

Do more with less is the main philosophy of the frugal production strategy. Nissan is continuously developing programs focusing on *muda* or eliminating waste and implementing best practices or *seri*<sup>6)</sup>. ‘Frugal’ is a concept of simplification and strives for less instead of more by using best practices (Chowdhury, 2019c, 9). Nissan also developed the ‘Nissan Production Way’ (NPW) to outline its synchronized production philosophy with a focus on ‘synchronization of quality, cost, elimination of waste and the reduction in lead times’. The purpose of the NPW is to achieve ‘boundless synchronization with customers and boundless exposure of problems and innovation’. In addition, synchronization has its emphasis on ‘produce when consume’. That means supply when demand, a never-ending quest to make just-in-time supply perfect. The idea was to improve the company’s productivity and effectiveness and have a global standard production system. In line with legislative provisions promoting the so-called 3R initiatives (reduce, reuse, and recycle), Japan’s automakers are also striving to design vehicles using lightweight materials that are easy to dismantle and recycle, and to reduce and recycle waste generated in the manufacturing process (JAMA, website). The scrap recycling expansion to material specifications also focused on recycle and re-use policies to frugal production practices.

In the other hand, *kaizen* philosophy, which is used where aims to eliminate the seven types of waste caused by overproduction, waiting, transportation, unnecessary stock, over processing, motion, and defective parts. It is very clear that *kaizen* principles and frugal principles both have the same goals. *Kaizen* supports the improvement of existing activities (Chowdhury, 2019c, 10). It is important for [a] firm to maintain a balance between innovation and a *kaizen* strategy that focuses on improvement (Cane, 1996). The Frugal approach is an approach to innovation which is based on the principle of simplification-finding solutions to a problem which solve the problem but without adding unnecessary costs or adding unwanted functions. ‘Frugal’ for the replacement and improvement of automated labor, is reducing production costs, decreasing production time and increasing efficiency which seem to agree with *kaizen* practices.

Nissan is emphasizing new design and technological challenges, the next step is reduction of production materials. Recently Nissan’s manufacturing of EV’s has been increasing and putting more focus on foreign markets. Nissan has implemented advanced automation throughout the production process in a shift to medium- and small-lot production of different models like the e-Power Note model for expand market.

#### 4.2. Affordable Market Strategy

Despite the high cost of vehicles, there are hundreds of thousands of Asian people who cannot afford cars. Frugal production can be achieved low production cost through reduction, elimination, the

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6) Seri or ‘Sort’ that advocates elimination of unnecessary tools, parts, and instructions by retaining only the essential items.

modification of manufacturing activities. Through in-depth analysis the best and lowest cost path must be adopted for each activity. The best method to achieve positive results is for auto-makers to reduce the number of unnecessary parts and goods. It is probably not that difficult to produce a vehicle with less parts and more functions (Chowdhury, 2019b, 77).

Renault-Nissan has proactively adopted frugal engineering—and established itself as a major global manufacturer of both low-cost vehicles as well as EVs. As mentioned above Renault launched Logan, the global small car and Tata Nano are gathering production and manufacturing techniques from both the Renault and Tata production systems, but and has generated a production system different from both. This can be called the Nissan's style of frugal production practice. Nissan auto makers have also tried to decrease costs and produce with less resources which is the main goal of frugal production.

#### **4.3. Quality Products**

The customer sees the price of a goods as an image of a cars quality and value. Growing importance of a product's quality depends on two factors. The first one is the national income: as nations prosper, consumers wish to buy not just a greater quantity of goods and services but also higher quality products. Frugal cost strategy refers to qualitative products of business strategy, through 'the design and development of EV products and services with price'. In addition, the frugal approach has to address the accessibility of new technologies, which it's ultimate purpose, leading to solutions concerning resources, production waste and finally low cost. Although frugal cost strategy is a novel approach to exploit new technology, because it (the strategy) becomes crucial to potential for expansion and future profits. (Chowdhury, 2019c, 10-11). Cost leadership strategy that has been used by many companies has led to less innovation and development of less customized and exclusive vehicle models. This may damage the brand reputation of those companies as consumers may associate the company with low quality products. To change this, those companies needs to shift to a product differentiation strategy. This will allow the production of vehicles that meet customer expectations and maintain a positive brand image. The new product strategy should be based on differentiation.

The Nissan Frugal production allows for not only cost advantage but also quality and reliability (in the market). There are a large number of people who prefer a brand product, more expensive, with a guarantee of quality, than a cheaper one, with a no-name brand. Moreover, the production, offers added value, high quality and also a higher price. People all around the world are familiar with Nissan, Toyota, Honda, Mitsubishi, Subaru, Daihatsu, Fuso, Hino, Mazda, Lexus, and many more. Despite this familiarity, it was noted that there is still only a low percent of Asian consumers who are able to high pay more for a product of high quality and a 'guaranteed origin'.

#### **4.4. Safety Vehicles**

The Nissan aims to build profitable the highest quality vehicle sold in order to achieve the maximum

possible customer satisfaction and thus ensure the prosperity of the company (Basu and Miroshnik, 2000). The elderly customers demand smaller, convenient, easy operate vehicle, for small or narrow roads. According to the United Nations, globally the number of people aged 60 years and over is projected to more than double by 2050 and those aged 80 years and over are expected to triple by 2050, compared to 2017 (The United Nations, 2017, website). In 2017, the share of the European population aged 60 years and over was 25 percent and this proportion is projected to increase up to 35 percent by 2050 (The United Nations, 2017, website). Nissan, have already made significant progress in adapting their EV technology to accommodate elderly consumer need and as mentioned above the first one pedal driving system - an optional system that allows you to transform the accelerator into an e-pedal to function as a start, stop, accelerate and brake pedal has been fitted.

The Nissan's has one of an important goal is no traffic accidents. 'No more accidents, no more driver fault, no more social life' are three of chief motives behind the company's continued innovation and cost down strategy (Chowdhury, 2019b, 76). It developed its first Experimental Safety Vehicle (ESV) in 1971, and has since won huge acclaim for its safety shield suite of technologies, which monitor an almost 360-degree view of the vehicle, warning the driver of potential hazards (Nissan website). In the area of mobility services, Nissan began conducting field tests of 'Easy Ride' autonomous driving in Japan with DeNA. These tests are a significant first step to enabling customers to experience real services and technologies. Guillaume Masurel, Marketing Director at Nissan Motor, stated that 'Nissan has always tried to do things a bit differently and in a more challenging way to bring new solutions to its customers'. Masurel believes these hugely successful vehicles highlight Nissan's continuing capacity for challenging conventions, while also 'keeping an eye on what the customer needs and what we can do differently to be more in line with that' (Nissan, website). Nissan is introducing ProPILOT<sup>7)</sup> new technologies and products through its Nissan Intelligent Mobility strategy, which maintain its EV leadership with a million vehicles sold per year, including both EVs and e-POWER. Executive officer of Nissan Hideyuki Sakamoto said, these new technologies and innovations are at the heart of the company's competitiveness (Nissan, website). This also seems to be a part of the frugal approach in production at Nissan.

Still, charging infrastructure is not widely available. However, Nissan's 'Use-hodai plan', offers more than 5,900 chargers nationwide for 2,000 yen per month (excluding tax / as of June 2019). Although most EV owners have access to a home charging point, public charging points are important for easy access. Japan has chosen to invest heavily in charging infrastructure, aiming to stimulate uptake.

A new evolution in EV is required, where frugal production strategy can be implemented beyond the realm of technological innovation to contribute to cost reduction, save resources, using a set of tools that

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7) ProPILOT 2.0 integrates a whole set of new technologies that required with five cameras including one trifocal camera, five radars, and 12 sonars for a 360-degree, real-time picture of the vehicle's surroundings. The system combines this with high-definition 3D map data that covers the number of lanes, merging and split points and intersections to provide a smooth driving experience (Nissan website).

is designed for doing more for less in relation to production practices. The design, development, and special parts for a new vehicle or major component are very costly. Financial returns must be made during the manufacturing process. Within a vehicle assembly plant, raw materials and components become complete vehicles. It would be logical to account for all the incoming materials, components, labor, supplies, utilities, and other costs and compare them to vehicle output. Every Nissan built vehicle is every bit as important as the individual cutting-edge technologies, sleek designs and safety features and the evolution in technology and quality. The leap forward will come from new and more complex driving assistance systems, daring new body structures made possible with e-POWER or fully electric powertrains, the use of lighter and stronger materials, and tighter fits and finishes.

## 5. Conclusion

Despite rapid growth, the EV market still remains small, reaching only a 1.3 percent share of global sales in 2017. In 2018, the global EV number exceeded 5.1 million units, up 2 million units from the previous year and almost doubling the number of new EV sales (IEA, 2019 website). The market is highly concentrated in China, Europe and the United States which together accounted for 94 percent of the total global market. China alone accounted for about 49 percent of global unit sales (Statoil, website). According to Goldman Sachs, the total number of vehicles on the roads in China and India could rise from 30 million in 2007 to 750 million by 2040 (Gupta, 2009, 204). In addition, the IEA (2019) noted that China maintains its world lead with 57 percent share of the EV market in 2018, followed by Europe 26 percent and Japan 21 percent. However, the global share of EVs is expected to increase significantly, driven by substantial battery technology improvements and the possibility to adopt frugal cost strategy that are accelerating the affordable EV markets in developed as well as emerging markets.

Renault-Nissan's global innovation network spans across France, India and Japan. In terms frugal cost strategy, the possibility of the Renault-Nissan Alliance creating frugal vehicles for global markets by integrating its engineers, with their strong project management skills from its Renault teams, and the deep technical expertise and innovative technology of its Nissan R&D seems / is an increasingly strong possibility. There are both opportunities and barriers to frugal cost strategy, for both incumbents and new entrants. From the above, it can conclude, Nissan has good opportunity to adapt frugal cost strategy to change of market (supply and demand) with respect to their EV production new growth opportunities.

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