

Advocate's Recommendation for the IEEE Milestone

#2022-19 "Toyota Prius, the world's first mass-produced hybrid vehicle"

February 15th, 2024.

Dear IEEE History Committee.

I'm honored to be an advocate to review for the Milestone Proposal, "Toyota Prius, the world's first mass-produced hybrid vehicle", #2022-19.

(1) Expert Reviewers:

I asked following three independent experts in the field of the proposal to conduct a detailed review from a technical point of view.

Prof. Yoichi HORI.

Contract Professor, Tokyo University of Science, IEEE Life Fellow.

Prof. Makoto IWASAKI.

Professor, Nagoya Institute of Technology, IEEE Fellow.

Prof. Jun SATO.

Professor, Nagoya Institute of Technology, IEEE Senior member.

(2) Reviewer's Reports:

I requested these expert reviewers feedback on four questions:

Q1) Is the suggested wording of the Plaque Citation accurate?

Q2) Is the evidence presented in the proposal of sufficient substance and accuracy to support the Citation?

Q3) Does the proposed milestone represent a significant technical achievement?

Q4) Were there similar or competing achievements? If so, have the proposers adequately described these and their relationship to the achievement being proposed?

Finally expert reviewer's conclusions.

I will address each below.

Q1) Is the suggested wording of the Plaque Citation accurate?

Prof. Yoichi HORI's comment:

"Yes, I agree that the following points, which will be included on the plaque, are accurate:

- In 1997, Toyota developed a mass-produced hybrid vehicle, the Toyota Prius.

- By recovering and reusing energy lost during deceleration, it achieved groundbreaking fuel efficiency.
- After the Prius, many hybrids vehicle were introduced and made significant contributions to reducing CO2 emissions from automobiles.”

Prof. Makoto IWASAKI ‘s comment:

“Yes. I support the content stated. The mass production of hybrid systems, which rely on precise control of the engine and electric motor to significantly improve fuel efficiency in automobiles, was a groundbreaking breakthrough at that time. The Prius has been widely accepted in society as an iconic eco-friendly car product.”

Prof. Jun SATO’s comment:

“Yes, the suggested wording of the Plaque Citation is accurate. It is a fact that Toyota's Prius introduced the first mass-produced hybrid car to the market in 1997. The electric motor-driven propulsion method has become one of the choices for fuel-efficient and low CO2 emission vehicles, and it has since sparked intense competition in technological development.”

Q2) Is the evidence presented in the proposal of sufficient substance and accuracy to support the Citation?

Prof. Yoichi HORI’s comment:

“Yes. The following three points are adequately demonstrated in the proposal and accompanying materials:

- Toyota began selling the Prius in 1997.
- The uniqueness of the hybrid mechanism and the improvement in fuel efficiency.
- At the time of release, the production scale was approximately 20,000 units per year, and there was subsequent expansion of hybrid vehicles by the company.”

Prof. Makoto IWASAKI ‘s comment:

“Yes. The originality and effectiveness of the series-parallel hybrid system are clearly stated in the proposal and supported by the referenced literatures.”

Prof. Jun SATO’s comment:

“Yes, it is evident from the proposed wording and the accompanying literature that Toyota developed and introduced a significantly fuel-efficient system by adopting a series-parallel hybrid compared to conventional internal combustion engines.

Q3) Does the proposed milestone represent a significant technical achievement?

Prof. Yoichi HORI's comment:

“Yes. This proposal is significant for the following reasons:

- Toyota became the first in the world to mass-produce a hybrid vehicle that utilizes both an internal combustion engine and electric power as the driving force.
- The hybrid vehicle achieved fuel efficiency improvements that were not possible with conventional internal combustion engines.
- Following the Prius, many hybrid vehicles were introduced to the market. The technology developed, including batteries, motors, and inverters, has become the foundation for electric vehicles such as Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCEVs).”

Prof. Makoto IWASAKI 's comment:

“Yes. Toyota's developed series-parallel hybrid system connects the engine and the motor-generator through a planetary gear mechanism. This mechanism enables smooth shifting without a traditional transmission, similar to a Continuously Variable Transmission (CVT), while this requires precise coordination of the engine's output and the motor-generator through intricate control. Given the short development period at that time, it was necessary for conventional automotive engineers specializing in combustion and mechanics to closely collaborate with electrical engineers to devise control systems tailored to the characteristics of each unit and ensure a smooth-running vehicle. I believe that it was through the advanced collaboration between engineers from these different fields that this hybrid system was realized.”

Prof. Jun SATO's comment:

“Yes, the practical application of the series-parallel hybrid was a significant breakthrough for automobiles at that time. Being a full hybrid (strong hybrid), it could run on electric motor power alone and also efficiently utilize the engine at optimal rpm, while recovering and reusing energy that would otherwise be wasted during surplus or deceleration. In other words, it was designed to achieve the most efficient energy balance for the entire vehicle, inspiring the current trend of high-efficiency cars.

Furthermore, Toyota continued to improve the hybrid system, equipping it in many vehicles and introducing them in large numbers to the market. This allowed them to establish the technology for motors, batteries, and inverters, which are now commonly found in modern electric vehicles.”

Q4) Were there similar or competing achievements? If so, have the proposers adequately described these and their relationship to the achievement being

proposed?

Prof. Yoichi HORI's comment:

“Yes. After Toyota successfully mass-produced their unique series-parallel hybrid system, other manufacturers also introduced hybrid vehicles to the market using different systems.

The differences between Toyota's hybrid technology and those of other companies, as well as the advantages of Toyota's hybrid technology, are clearly stated in this proposal.

With the introduction of the Prius, awareness of eco-friendly cars increased in the automotive industry, and fuel efficiency became an important criterion for users when choosing a vehicle. It is considered a historic achievement that has changed the landscape of the automotive industry.”

Prof. Makoto IWASAKI 's comment:

“Yes. As mentioned in the proposal, hybrid technologies have been developed by other manufacturers as well. However, other companies used parallel hybrids, which added motors to the combination of a conventional engine and transmission, or added a clutch between the engine and motor to enable motor-only operation. There was no other series-parallel hybrid that used a planetary gear system like Toyota's hybrid system. This system has been incorporated into many hybrid vehicles since then, indicating the high potential of the system developed at that time. Toyota's unique approach also includes the free licensing of patents related to components and controls that have been cultivated over more than 20 years since its launch, contributing the widespread adoption of excellent technologies.”

Prof. Jun SATO's comment:

“Yes, at that time, many other companies had parallel-type hybrids or ones with the same transmission as conventional cars. There were no other series-parallel hybrids that used a planetary gear system like Toyota's hybrid system. Toyota has continued to adopt a similar principle for its hybrid system, with improvements in the performance of each component. This suggests that the system developed at that time was superior.”

Expert Reviewer's Conclusions:

Prof. Yoichi HORI's comment:

“As stated above, this achievement has had a significant impact on the automotive industry. Creating a hybrid vehicle that would be accepted in the market at that time was a project that was ahead of its time and required significant technological breakthroughs. I strongly recommend registering this proposal as an IEEE Milestone.”

Prof. Makoto IWASAKI 's comment:

“Overall, of the assessments above, I believe that the Toyota Prius described in this proposal is a very

important product in the history of human technology, and I strongly recommend that this would be recognized as an IEEE Milestone.”

Prof. Jun SATO’s comment:

“Finally, the proposal of “Toyota Prius, the world’s first mass-produced hybrid vehicle” is well written and clearly shows the superior technical impact to all over the world brought by Toyota Prius. As a reviewer I strongly recommend this proposal to IEEE Milestone.”

(3) Discussions on the ETHW Website:

Supporting comment by Dr. Ichiro Matsubara:

“I believe that the Toyota Prius, the world's first mass-produced hybrid car, is fully deserving of the IEEE Milestone recognition. At a time when internal combustion engines dominated the automotive industry, Toyota took a forward-looking approach to address future environmental issues by combining an internal combustion engine with an electric motor, resulting in a significantly improved fuel efficiency and successfully mass-producing a car with such a drivetrain system. This achievement holds great significance. Furthermore, starting with the Prius, hybrid cars have become one of the mainstream options in the automotive industry. This has led to an increased demand for electrical components such as motors, inverters, and batteries, as well as the creation of demand for high-performance materials like magnets and semiconductors, thereby contributing to technological advancements.

Dr. Ichiro Matsubara, Director – General, National Institute of Advanced Industrial Science and Technology (AIST) Chubu”

Supporting comment by Prof. Kenji Yamaji:

“I believe that the Toyota Prius, proposed for the IEEE Milestone, is deserving well of recognition for the following reasons, and I highly recommend it.

When Toyota introduced the mass-produced hybrid vehicle Prius to the market in 1997, its fuel efficiency was approximately double that of other vehicles with the same engine displacement. This milestone event resulted in a 50% reduction in CO2 emissions per unit of distance traveled, which was revolutionary at the time. The Prius also served as a catalyst for other automakers to develop environmentally friendly vehicles. It is undeniable that the Prius was an epoch-making car that introduced environmental performance as a purchasing criterion in the market, setting a precedent for others to follow.

Prof. Dr. Kenji Yamaji, President, Research Institute of Innovative Technology for the Earth.”

Supporting comment by Mr. Hideyo Kunieda:

“As the Program Officer of Sustainable area in the JST (Japan Science and Technology Agency) Mirai program, I would like to support the proposal of the subject entitled “the World's First Mass-Produced Hybrid Vehicle” as an IEEE milestone. In 1990's, automobile is mostly powered by the internal combustion engine with much CO2 exhaust. The release of mass-produced hybrid vehicle opened a new era of mobility with much less environmental impact. It is partly because of the best combination of an internal combustion engine and an electric motor, and partly because of the regenerative break. For the sustainable society, this gave a great step forward by accelerating the developments of electric motors, high performance batteries and inverters and so on. At our synchrotron radiation facility, more than half of research subjects are related to these issues with industry-academia collaborations. This trend well matches with the direction of the Sustainable Development Goals (SDGs) proposed in 2015. In the future, hybrid vehicle should be one important choice of power system of automobile, especially under the environment without enough infrastructure and power grids.

Hideyo Kunieda Director of Aichi Synchrotron Radiation Center Program Officer of Sustainable area in the JST* Mirai program (*Japan Science and Technology Agency)”

Recommendation by Mr. Chris Mason:

“I am the Chief Executive Officer of FISITA, a position I have held since 2014. FISITA is the international membership organization for the automotive and technology of mobility industry and has supported its technical community since 1948. We are proud to report that the Toyota Motor Corporation has been a valued, leading member since 1995.

I write to you today to recommend recognizing the Toyota Prius, which was launched in 1997, as an IEEE Milestone for its significant impact on the history of automobiles as an electric vehicle.

The Prius was the world's first mass-produced hybrid car, and Toyota's adoption of hybrid technology paved the way for advancements in various technical aspects of vehicles, including engines, motors, batteries, and other electronic components.

It is not an exaggeration to say that the birth of the Prius also served as a starting point for the overall electrification of vehicles, which is essential for technologies like driver assistance and safety.

Moreover, the Prius introduced environmental performance into the automobile industry, which was primarily focused on driving performance at that time. It became a pioneer in efforts to reduce environmental impact and brought a sense of value to cars in terms of their environmental performance.

Yours sincerely

Chris Mason, Chief Executive Officer FISITA”

Supporting comment by Dr. Yoshiko Kojima:

“I believe that the Toyota Dr. Yoshiko Kojima Prius is fully worthy of IEEE Milestone certification. I think it was an innovation in drivetrains that allowed us to introduce an electric powertrain to a mass-

produced car for the first time. Furthermore, it is worth mentioning that they adopted the excellent idea of connecting the motor and engine with a planetary gear without using a clutch, and were able to commercialize this idea with precise control. Nowadays, the importance of electrification is being touted, but there is no doubt that the hybrid systems released over 20 years ago were the beginning of a new era. Hybrid systems tend to be the focus, but what made hybrids possible was the ability to create high-voltage inverters. This required innovations in power semiconductors, and also in electronics. Hybrid cars have made it possible to introduce high-voltage systems into cars, which has also led to the development of electric vehicles such as PHEVs, BEVs, and FCEVs. Today's cars are equipped with many functions such as various controls, driving support devices, and multimedia, and it is necessary to manage them. The electrification of cars has also led to increased compatibility with such devices that will come later.

Dr. Yoshiko Kojima, IEEE ITSS Nagoya Chapter Chair”

Support comment by Mr. Yuichi Azuma:

“Toyota's mass production introduction of the Prius hybrid vehicle in 1997 is highly recommended as worthy of IEEE Milestone recognition. In the 1990s, some automakers recognized the need for significant improvements in fuel efficiency due to concerns about dwindling oil reserves. Toyota's commercialization of hybrid cars, followed by Honda's entry into the market with mass-produced cars, created a trend toward environmentally friendly development. The environmentally friendly technologies created by each company's development have been indispensable technologies for today's automobiles. This has led European and American car manufacturers to increasingly focus on hybrid vehicles. Even today, in regions where the infrastructure for producing electricity with low CO2 emissions is not in place, hybrid vehicles are an effective means of reducing CO2 emissions from automobiles. I believe this event marks a pivotal point in the history of automobile development, turning hybrid cars into the automotive industry's mainstream powertrain.

Yuichi Azuma, Executive Director, Society of Automotive Engineers of Japan.”

(4) Advocate's Comment and Conclusion:

I received the above satisfactory peer review results from three experts in the field of proposals.

I received many comments on the discussion page of the ETHW Website, too.

These expert reviewer's reports and discussions were very useful for my decision as an advocate for Milestone 2022-19.

Citation:

Three expert reviewers responded that citation is accurate, judging by the answers to question Q1.

They also reported that they confirmed that the contents of the citation are supported by evidences,

judging by the answers to question Q2.

As an advocate, I have the same judgments as reviewers, too.

Technical significance and historical value:

Three expert reviewers gave me detailed reviews of the answers of Q3 and Q4.

In addition, there were many support comments posted on the discussion page of the ETHW Website.

They explained the technical significance of the Toyota Prius as the world's first mass-produced hybrid vehicle, and the historical value was explained, too.

Advocate's Conclusion:

All three expert reviewers gave the proposal strong recognition and support that it deserves the IEEE Milestone certification. Of course, I also consulted many comments on the ETHW Website.

I have considered carefully both the proposal and the expert reviewer's reports, and have the same thought as expert reviewers.

In conclusion, I strongly recommend this proposal to the IEEE Milestone as an advocate.

Best regards,



Dr. Tomohiro Hase, IEEE Fellow.

Advocate #2022-19, IEEE History Committee.