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Profile Of Solar Panel Recycling Technology

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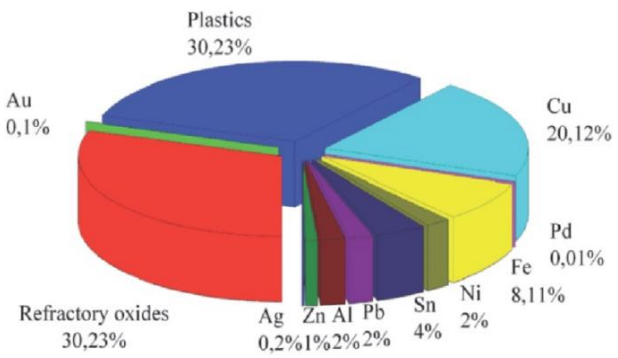
Abstract – Renewable energy is one of the main forms of energy sources in today's world, with solar energy being the most popular because of its abundance and easy access to solar panels. With so many solar panels in use, disposal of them after their lifetime is a hassle and results in wastage of important components. This project gives the profile of solar panel recycling and way to utilize the important components in a solar panel after its.lifetime. Result – This technology helps us to utilize important components from a solar panel or even re-use the whole panel using solar cell technology. Metals like Silver, Lead can be restored and re-used saving precious resources and capital cost. Proper recycling also helps to prevent environmental pollution.

I. INTRODUCTION

After The Advent of the 21th Century, Humanity has ventured into The Digital Age. The World is Surrounded by Phones, Tablets, Computers, and other electronic equipment all the time. A Major Issue that Flies under the Radar is the sheer amount of Electronic Equipment that are being Manufactured every year throughout the globe. Irreparable Cell phones, Dysfunctional Printers or even a simple Battery that has reached its end is considered E-waste.

When they approach the End of their Life-Cycle, These Items are termed as E-waste and are often Burnt, Dismantled or Even Dumped into Landfill Sites. The small amount of E-waste that is set aside for recycling is often left untreated as there is negligible awareness regarding E-Waste Management. With the Amount of E-Waste Increasing Exponentially, this is bound to be a major problem of the ongoing decade and it is fitting that we come up with a solution just as fast as the problem proceeds. India Generates approximately 32 Lakh Tonnes of E-Waste in 2019[x] .Not only does this have Environmental Adverse Effects but this also affects Human Life to a Moderate Extent. Exposure to the Harmful Emissions from E-Waste Incineration and Consumption of Food grown in Arsenic/Lead Influenced Soil will mess with the person's internal composition. As e-wastes are the known major source of heavy metals, hazardous chemicals, and carcinogens, certainly diseases related to skin, respiratory, intestinal, immune, and endocrine and nervous systems including cancers can be prevented by proper management and disposal of e-waste. It has been shown that the development of the e-waste management system depends on both greater public awareness and manufacturer participation. Governments oversee allocating enough funds and enforcing within their borders the environmental laws that have been accepted worldwide.



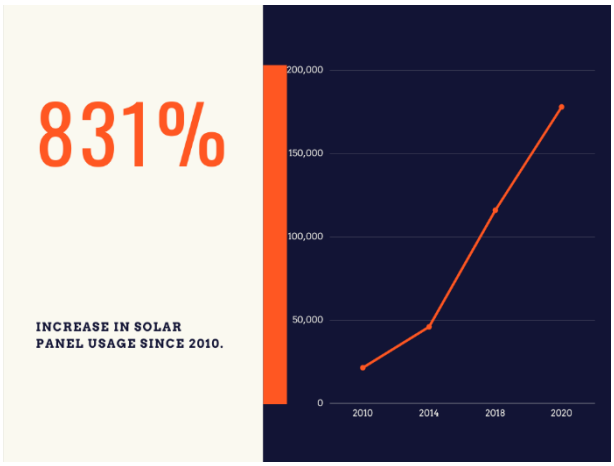
Through this Project we Intend to Shed Light on Some Scientifically Verified Methods Which Provide the Safest Ways to Recycle E-Waste Significantly. To make the Project more impactful we will Consider only one E-Waste component at a time. For Instance-Let us Try a Solar Panel.

The Following Parts of the Project will convey how We can Make Maximum Profits out of a Solar Panel by Recycling It Additionally We will be looking to compare all three methods and find out what the Better Method is based on economical, practical, and functional conditions. Before Delving into the Recycling Methods, we should be acquainted with The Base-Line Knowledge of how Solar Panel Recycling is done Conventionally and what it is Plus-Points and Drawbacks are.

II. NEED OF SOLAR PANEL RECYCLING

On the Surface, Solar Panel Recycling seems like a Problem of the Far Future. And if that is the issue, why do we need to worry about it in the present?
On an Average, Solar Power accounts for 13.22%[II] of Total Energy Used In India. India Averages 50 thousand Solar Panels in 2021 and that number must have increased significantly in the recent 2 years. Considering that An Average Lifespan of a Standard Solar Panel is 30 Years, it is quite a bold assumption to think that Solar Panel Recycling is not that much of a great problem. In the not-so-distant future (the next 10 years) the previously installed solar panels will start coming down and accumulating. If We do not find an efficient way to deal with the horde of Solar Panels that will lose function, we may face a very huge problem.

Recycling or repurposing old solar panels has the potential to unlock a huge, invaluable stock of raw materials soon. In fact, according to a recent study conducted by the International Renewable Energy
Agency (IRENA) the recyclable materials in old photovoltaic solar models (like indium and gallium) will be worth $15 billion in recoverable resources by the year 2050[iii] .The future of renewable energy is in the recycling of photovoltaic panels. We must act accordingly if we want to build a better future.



Therefore, it is necessary that we Adopt a Pre-Existing Method or create an Entirely New One that solves this issue. Through this project, we intend to find a Economically Sustainable and Scientifically
Applicable Method to Successfully Recycle (Part of, if not all of) A Solar Panel.

The Following Parts of the Project will convey how We will be comparing all methods and find out Pros and Cons of all methods based on economical, practical, and functional conditions. Before Delving into the Recycling Methods, we should be acquainted with The Base-Line Knowledge of how Solar Panel Recycling is done Conventionally and what it is Plus-Points and Drawbacks are.

III. WAYS OF SOLAR PANEL RECYCLING AND APPLICATIONS

Solar Panel Recycling has been a Craft mastered by many other countries. Studying the different processes adapted by these countries and comparing them later on can help us in Finding the best method to implement in India regarding Solar panel recycling. Glancing and reviewing through the Information Made Available through the Internet, We can Infer 3 methods which are the recommended to recycle solar panels, these methods are as follows:

I. Mechanical Recycling: Mechanical recycling is the most common method, which involves mechanically separating different materials in solar panels. The panels are crushed and broken down into smaller pieces in this process, and different materials such as glass, aluminium, and silicon are separated using mechanical processes. The materials can then be reused in the production of new solar panels, repairing of older solar panels, or making new products.

II. Thermal processing: Thermal processing involves the use of high temperatures to break down the solar panels. Pyrolysis and incineration are two thermal processing methods. Pyrolysis involves heating the panels in the absence of oxygen, which causes the materials to degrade. The panels are incinerated at high temperatures, and the resulting ash is used to make other products. High temperatures, and the resulting ash is used to make other products.

III. Chemical Processing: This method uses chemicals to separate the materials in the solar panels. This process is called Hydrometallurgy. The panels are first broken down into small pieces and then treated with chemicals to separate the different materials. The materials can then be reused in the manufacturing of new solar panels or other products.

The choice of technique depends on several factors such as the type of solar panels, the amount of waste generated, the purity of the materials required, and the economic viability of the process.

The European Union is way ahead of other in terms of methods to deal with Photovoltaic Waste. The Waste Electrical and Electronic Equipment (WEEE) Directive of the EU imposes responsibility for the disposal of waste on the

manufacturers or distributors who introduce or install such equipment for the first time. In the EU countries the PV Manufacturers are the same people who will collect and recycle the PV modules once they are no longer working.

In the USA, there are a few states who established policies to recycle Solar Panel Waste.

States of Washington and California hold the manufacturer responsible to sponsor the handling and reuse of PV modules which can be re-sold. All other countries like Japan, South Korea and Even Australia have generated funding to deal with the issue.

Meanwhile in India Solar Panel Recycling is overlooked as recycling a solar panel cost between $20 and $30 while the easier yet hazardous option of sending it to a landfill costs $1-2.

Economic Problems Aside, another huge problem is that a lot of places within the country consider dysfunctional solar panels as hazardous waste material and refuse to hand it over to concerned authorities unless some rules and regulations are followed. This gives an unrequired headache to the recycling authorities.

Incineration of a Solar Panel leads to production of poisonous fumes which have carcinogenic effects on the human body and prolonged exposure will prove fatal.

Through the Years, Proposals were being made to implement a system that causes recycling of a solar panel as it is. That means the expired Solar Panel will undergo Minor Technical Repair- Glass pane will be changed, photovoltaic cells will be enhanced, not replaced. Such an idea is very good when you read about it on paper. However, its in-real-life implementation is very difficult as India isn't equipped with a plant to do it.... yet. India will aim to build a Solar Panel Plant which both Produces and Recycles Solar Panels in the next 20 years or so as it is the need of the hour. Another Demerit of recycling is that Buyers are very conscious about what they buy and when they are told it's a used solar panel, they are discouraged to buy it even if there is no difference between a brand-new panel and one that has been recycled.

The Conventional Approach has now become a complex process with the Glass and Aluminium being recycled easily but the other parts being extracted on a large scale in a time-consuming effort. Silicon, Lead and Silver parts undergo incineration for Extraction-the effects of which have been discussed above.

If this is our approach to Solar Power, it will do us more harm than good. The effects will not be visible until the next 15-20 years but once that period is gone through, it will be a serious problem. Hence it is advisable to find a solution before the problem becomes mainstream. The Government of India and the Major Players of the Private Sector must get together and come to an economically and environmentally sustainable Recycling Model. One that is easy going on both Humans as well as Nature.

IV. ADVANTAGES OF SOLAR PANEL RECYCLING

India has been making significant strides in adopting solar energy to power its growing economy. With the country's commitment to generating 450 GW of renewable energy by 2030[IV] there has been a rapid increase in the installation of solar panels. As solar panels have a lifespan of around 25-30 years[i] ,the increasing number of decommissioned solar panels raises concerns about their disposal. However, this problem can be addressed by solar panel recycling, which offers several advantages.

Firstly, solar panel recycling helps in reducing the environmental impact of solar panel disposal. Solar panels contain materials like glass, silicon, and metals, which can be hazardous to the environment if not disposed of properly. These materials can pollute the air and water, which can be detrimental to human and animal health[V]. Recycling these panels can help prevent these materials from ending up in landfills and leaching into the environment.

Secondly, solar panel recycling can help India conserve its natural resources. Solar panels contain valuable materials like silver, copper, and silicon, which are non-renewable resources. By recycling these materials, India can reduce its dependence on imports and ensure the sustainable use of its resources. This can also help reduce the cost of solar panel production, making it more affordable for the common man.

Thirdly, solar panel recycling can create new employment opportunities. India is a country with a large population, and unemployment is a significant challenge. However, recycling solar panels can create new jobs in the country, especially in the areas of research and development, dismantling, and recycling. This can contribute to the country's economic growth and help in achieving its sustainable development goals.

Fourthly, solar panel recycling can help India meet its waste reduction targets. India generates a significant amount of waste, and most of it ends up in landfills. However, recycling solar panels can help reduce the amount of waste generated by the solar industry. This can help India achieve its waste reduction targets and contribute to a cleaner environment.

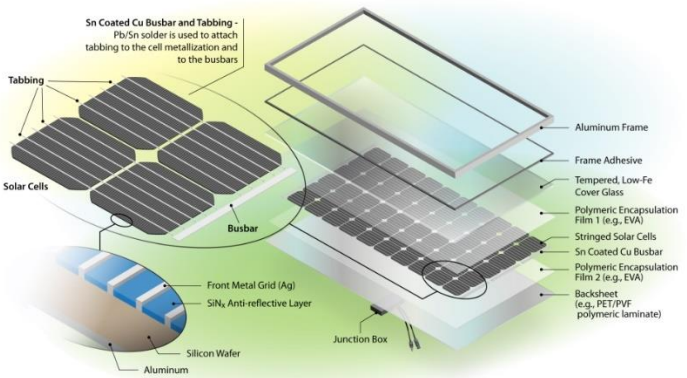
Finally, solar panel recycling can contribute to India's climate change mitigation efforts. The increasing adoption of solar energy can help India reduce its carbon footprint and mitigate the effects of climate change. However, decommissioned solar panels can release greenhouse gases during disposal, offsetting the benefits of solar energy[VI]. Recycling these panels can help mitigate this issue and contribute to India's climate change mitigation efforts.

In conclusion, solar panel recycling offers several advantages in India, including reducing the environmental impact of solar panel disposal, conserving natural resources, creating employment opportunities, meeting waste reduction targets, and contributing to climate change mitigation efforts. The government and the solar industry should work together to establish a robust recycling infrastructure and raise awareness among consumers about the importance of solar panel recycling. By doing so, India can achieve its sustainable

development goals and contribute to a cleaner and greener future.

V. BEST METHODS FOR SOLAR PANEL RECYCLING

As Inferred from above, Major part of a Solar Panel is easily recycled but the remainder is very hard to recycle. Any method that recycles the remainder of a solar panel efficiently should be adopted by Us for Benefit.



Method 1: Mechanical recycling is a widely used method for recycling solar panels. In this process, the solar panels are broken down into smaller pieces, and different materials such as glass, aluminium, and silicon are separated using mechanical processes. These materials can then be reused in the manufacturing of new solar panels or other products.

Several environmental and economic benefits. Firstly, it reduces the amount of waste that goes into landfills. Solar panels contain valuable materials that can be recovered through recycling. By recycling these materials, we can conserve natural resources and reduce the need for mining new raw materials. Moreover, the recycling process consumes less energy and emits fewer greenhouse gases than the production of new materials from scratch, reducing the carbon footprint of the solar panel industry.
Secondly, mechanical recycling has significant economic benefits. The recovery of valuable materials from solar panels can help reduce the production costs of new solar panels. Recycling can also create job opportunities in the recycling industry, as the process requires specialized skills and knowledge. The growth of the recycling industry can lead to job creation in various areas such as research and development, waste collection, and recycling facilities. In conclusion, mechanical recycling is an essential method for recycling solar panels. It offers significant economic and environmental benefits, including reducing production costs, conserving natural resources, and reducing greenhouse gas emissions.

Method 2: Thermal processing:
A method used in recycling solar panels, which involves the use of high temperatures to break down the solar panels. There are two thermal processing methods: Pyrolysis and Incineration. In Pyrolysis, the panels are heated in the absence of oxygen, which breaks down the materials. In incineration, the panels are burned at high temperatures, and the resulting ash is used to create other products.

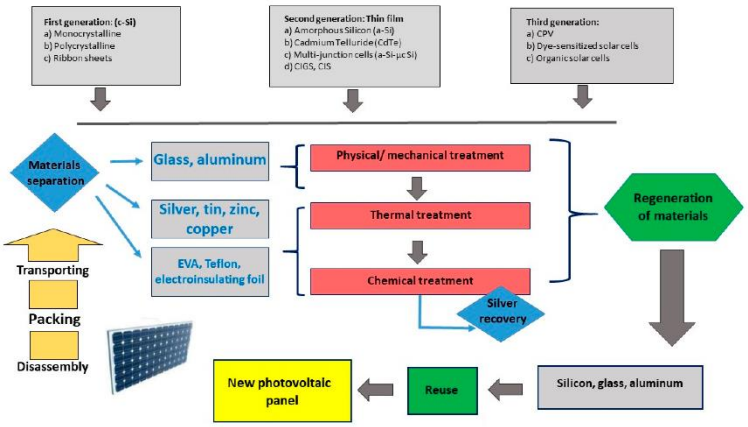
Thermal processing has both environmental and economic aspects. On the environmental side, it has the advantage of being able to process almost any type of solar panel, including those that are difficult to recycle through other methods. Moreover, thermal processing can produce energy from the waste generated during the process, making it a potential source of renewable energy.

On the economic side, thermal processing can recover valuable materials from solar panels that can be used in the manufacturing of new solar panels or other products. The process can also create job opportunities in the recycling industry, especially in areas such as waste collection and processing, and the operation of thermal processing facilities. In conclusion, thermal processing is a promising method for recycling solar panels, with both environmental and economic benefits.

Method 3: Reusing Individual components into products The Method Most Used throughout the world In Other Countries consists of the heavier materials of the Solar Panel (Glass, Aluminium, Silicon, Lead, etc) being recycled but not into other solar panels. These Materials are used in applications elsewhere.

- Greenhouses: The Glass used in Solar Panels Can be recycled into greenhouses which are used to maintain the temperature.
- Silicon: The Silicon Extracted is very valuable for the Computer and IT industry as it is a major component in the Microchip Industry which is an integral component of computer.
- Aluminium: Aluminium is an everyday material and can be used to manufacture cans, foils, kitchen utensils, window frames, beer kegs and aeroplane parts.
- Lead: Lead is still widely used for car batteries, pigments, ammunition, cable sheathing, weights for lifting, weight belts for diving, lead crystal glass, radiation protection and in some solders. It is often used to store corrosive liquids.

Photovoltaic Cell: It can meet the need for electricity for parking meters, temporary traffic signs, emergency phones, radio transmitters, water irrigation pumps, stream-flow gauges, remote guard posts, lighting for roadways, and more.



VI. LIMITATIONS OF SOLAR PANEL RECYCLING

Since the commercialization of Solar Energy since the 2010's, Solar Panels have upgraded over time, yet their recycling methods have stayed dormant with close to none developments in this regard. The need to Recycle Solar Panels is high right now than it ever has been. However, it is being shrugged off as it is not a profitable venture. Most of the large-scale Solar Panel Recycling Plants in India (active for 10+ years) are being run with losses.

80% of a General Solar Panel (the glass panes, Aluminium Frame and Copper Wiring) is very convenient and easy to recycle[VII]. However, the remaining 20% (Silver, Silicon, Toxic Lead, Etc) Are the Elements Making the Solar Panel Expensive. Inability to recycle these elements lead to a monetary loss in developing a sustainable recycling model for the Solar Panel Industry. The current Recycling Model produces a rough $3 per panel while the production cost is a whopping $25[VIII].An efficient Recycling Model should look to recycle anywhere between 50-75% of the material's monetary value.

Economic Problems Aside, another huge problem is that a lot of places within the country consider dysfunctional solar panels as hazardous waste material and refuse to hand it over to concerned authorities unless some rules and regulations are followed. This gives an unrequired headache to the recycling authorities and further discourages them from taking up the task. Such Solar Panels are then either Dumped or Incinerated. After being Dumped, the Toxic Lead which is a significant component of the Solar Panel seeps to the soil over a large period of time and pollutes the land, making it barren. Incineration of a Solar Panel leads to production of poisonous fumes which have carcinogenic effects on the human body and prolonged exposure will prove fatal.

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VII. FUTURE OUTLOOK

Discuss the future outlook for solar panel recycling, including emerging technologies and policies, and the potential for growth and development of the recycling industry.

The future of solar panel recycling in India looks promising, as the country aims to achieve its renewable energy targets and minimize the environmental impact of solar panel waste. The Indian government has taken several initiatives to promote the recycling of solar panels, including the formulation of policies and regulations to govern the recycling industry.

One such policy is the Extended Producer Responsibility (EPR) framework, which makes it mandatory for solar panel manufacturers to collect and recycle their end-of-life products. This framework has been implemented by the Ministry of Environment, Forest and Climate Change (MoEFCC) and requires manufacturers to submit a plan for the collection and recycling of their products to the Central Pollution Control Board (CPCB).

In addition to policy measures, there are also several technological advancements that are driving the future of solar panel recycling in India. These include the development of more efficient and cost-effective recycling technologies, such as chemical processing and advanced thermal processing methods.

Moreover, there is also growing awareness among consumers and the industry about the importance of sustainable practices, including the responsible disposal and recycling of solar panels. This awareness is leading to increased demand for sustainable products and driving the growth of the recycling industry in India.

The future of solar panel recycling in India is also closely linked to the growth of the solar industry itself. India is one of the fastest-growing solar markets in the world, with the government targeting a solar capacity of 100 GW by 2022.

As more solar panels are installed and reach the end of their lifespan, the demand for recycling services is expected to increase.

There are also opportunities for innovation and research in the field of solar panel recycling in India. The country has a large pool of talented scientists and researchers, and there is potential for them to develop new recycling technologies and processes that are more efficient and cost-effective.

However, there are also challenges that need to be addressed to ensure the future of solar panel recycling in India. One such challenge is the lack of infrastructure for recycling, particularly in rural areas where the majority of solar panels are installed. This can make it difficult and expensive to transport and recycle solar panels, and may lead to illegal disposal.

Another challenge is the need for greater awareness and education about the importance of recycling among

consumers and industry stakeholders. This can be addressed through public awareness campaigns and educational programs that highlight the benefits of recycling and the environmental impact of solar panel waste.

In conclusion, the future of solar panel recycling in India looks bright, with policy measures, technological advancements, growing awareness, and a growing demand for sustainable products driving the growth of the industry. However, there are also challenges that need to be addressed, such as the lack of infrastructure and the need for greater awareness and education. With the right policies and investments, India has the potential to become a leader in the sustainable management of solar panel waste.

VIII. CONCLUSION

Even though the current system for recycling solar panels is difficult and inefficient, breakthroughs in solar technology are still being made. The fact that solar panels now have a lifespan of 25 to 30 years implies that there is still plenty of time for the industry to make the necessary changes and modifications before most solar panels reach the end of their useful lives. This is good news for the environment. Besides recycling, it is crucial that we take all reasonable steps to lessen the impending e-waste excess. The average household may have an impact by conserving energy and, if feasible, recycling old solar panels by the methods mentioned in the study.

The future of renewable energy is in the recycling of photovoltaic panels. We must act accordingly if we want to build a better future. We May see newer methods being introduced in the not-so-distant future and be able to accept a single perfect method for recycling a complete 100% of a solar panel.

For instance, the National Research Energy Laboratory has begun researching a high-value, integrated recycling system[IX]. The technology's main goal is the high purity extraction of all materials and components. Scholars, supporters of solar energy, and supporters of clean energy all agree with this idea. While being in the early phases of research, this technology has the potential to completely transform the market and eliminate issues with solar panel recycling.

But even at the earliest this technology could take 10-15 years to be implemented at the scale at which it should be. India is expected to be having a Minimum of 12 thousand new solar panels in 2024. At such a high increasing rate we are bound to be Worried about recycling the massive waste at the earliest instead of being bombarded with the sudden rise e-waste and recycling problems in the year 2030

IX. REFRENCESES

[1] https://www.forbes.com/home-improvement/solar/how-long-do-solar-panels-last/#:~:text=The%20industry%20standard%20for%20most,for%2025%20years%20or%20more

[2] https://www.mercomindia.com/share-solar-rises-india-power-capacity

[3] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_IEA PVPS_End-of-Life_Solar_PV_Panels_2016.pdf

[4] https://energy.economictimes.indiatimes.com/news/renewable/india-needs-a-doubling-of-installs-to-deliver-on-pm-modis-450-gw-by-2030-ambition/96246672#:~:text=India%20installed%20a%20record%2015,capacity%20of%20US%24500bn

[5] https://www.intechopen.com/chapters/68288

[6] https://www.economist.com/science-and-technology/2016/12/10/how-clean-is-solar-power

[7] https://www.downtoearth.org.in/blog/energy/recycling-solar-panels-needs-boost-from-indian-policymakers-84999#:~:text=According%20to%20International%20Renewable%20Energy,and%20metal%20frames%2C%20are%20recyclable

[8] https://hbr.org/2021/06/the-dark-side-of-solar-power

[9] https://www.nrel.gov/news/press/2020/nrel-research-points-to-recycling-solar-panels.html

[10] https://bridgetoindia.com/report/managing-indias-pv-module-waste/

Additional links:

https://www.researchgate.net/figure/Comparison-of-cost-and-revenue-breakdown-for-recycling-five-different-Si-PV-modules-using_fig3_332698777

https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling

https://www.psmarketresearch.com/market-analysis/solar-panel-recycling-market

https://www.marketresearchfuture.com/reports/solar-panel-recycling-market-6701

https://www.databridgemarketresearch.com/reports/global-solar-panel-recycling-market

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