OCTOBER 2022

GTTSi

Global Technical Training Services, Inc. Newsletter

The State of the Industry

Sid Crouch, GTTSi Chief Technical Consultant

In California, lawmakers took action to keep Diablo Canyon operating with the passage of Senate Bill 846, but much more is required to get this accomplished. Hopefully, this action was not a “day late and a dollar short.” One major hurdle for PG&E was completed - they submitted their application for the DOE’s Civil Nuclear Credit (***CNC***) Program. As a first-round applicant they will have a shot at a share of the $6 billion funds available. However, the earliest a CNC decision will be made is October 6th and they still have other issues to deal with that include the NRC, FERC, and NERC – not to mention ordering new fuel.

In Michigan, the possibility of restarting Palisades has arisen. When Palisades was shut down, their license was transferred to Holtec International for decommissioning operations. However, after review of the intricacies within the Inflation Reduction Act, they see the possibility of restarting Palisades. In cooperation with “the state, federal government, and a yet to be identified third-party operator” they are investigating this possibility. Plans for decommissioning, however, continue to progress.

In Georgia, Southern Company announced that their plans to seek license renewal for their two reactors at Plant Hatch and Vogtle Unit 3 have been approved for “Initial Fuel Load” by the NRC.

And finally, the NRC returned to its full five-member complement, with the Senate’s approval of Annie Caputo and Bradley R. Crowell.

I welcome your comments or questions - sid.crouch@gttsi.com

Highlights

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SPENT NUCLEAR FUEL – A STRATEGIC RESERVE – NOT WASTE!

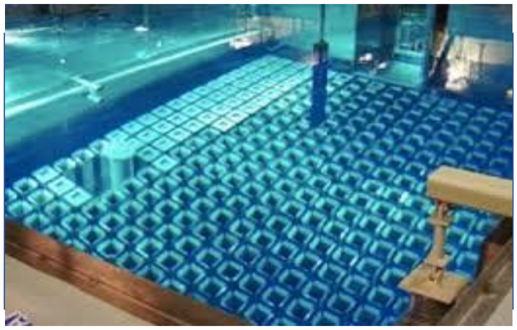
Let's talk about Nuclear Fuel since nuclear energy is one of the largest sources of emissions-free power in the world. In the U.S., it provides more than half of our emissions-free energy while generating nearly a fifth of our electricity.

To do this, we primarily use uranium as the fuel source. Uranium exists in nature as two isotopes: the less common U-235, and the more common U-238. Conventional reactors split U-235 to produce power, and the U-238 in some cases absorbs a neutron from the fission process, to become U-239 (just an isotope of Uranium with one extra neutron than U-238) which in turn beta-decays quickly to becomes Np-239 (***Neptunium***). Then the Np-239 beta-decays again to become Pu-239, which is a fissile isotope, similar to U-235. Therefore as the reactor operates, Pu-239 is produced and contributes to the reactor as a fuel source - eventually providing about 45% of the energy produced.

At the end of the typical fuel cycle (***12-18 months***) about one-third of the total fuel assemblies in the reactor core are replaced with new fuel assemblies. Therefore, about one-third of the used fuel assemblies are taken out of the reactor core and stored in the "Spent Fuel Pool." The result – only about 5% of the reactor fuel is actually used and the spent fuel assembly is stored in the Spent Fuel Pool until its radioactivity level has reduced to a level where it can be stored in a Spent Fuel Cask which is located outside and is air-cooled.

However, there is a way to use almost all of the fuel source that remains in a spent fuel assembly – recycling. If we recycled the used nuclear fuel already available, we could provide enough fuel for our reactors for hundreds of years - all of it carbon-free. The problems with the older recycling technology and the nation's concern over proliferation put a halt to the idea of recycling in the U.S. in 1977, but new techniques developed by scientists at the U.S. Department of Energy's (***DOE***) Argonne National Laboratory address many of those issues.

One of the reasons why so little fuel is used is that almost every commercial reactor today is a light-water reactor, or LWR. LWRs are good at many things, but they rely on "thermal neutrons" for fissioning. Many of the fissionable fuels produced during the LWR fission process would require "fast neutrons" for fissioning.(***continued***)



Spent Fuel Pool – One Assembly Going In

Delivery of Spent Fuel Cask to the Cask Farm

Fast Reactors, utilizing fast neutrons, could burn our spent nuclear fuel; however, fast reactors use a different coolant, such as sodium or lead. This coolant doesn't slow the neutrons as much, and consequently, the reactor can fission a host of different isotopes. This means that fast reactors can get electricity out of many kinds of fuel, including all that leftover used fuel from LWRs. (***LWRs can burn recycled fuel too, with some modification, but they aren't as good at it***.)

If we built fast reactors, it would be entirely possible to take all the used fuel we've generated over the past 60 years, currently stored at reactor sites, and feed it back into fast reactors. Some of it would still need to be permanently stored, but far less; recycling all the uranium and other actinides would reduce the volume of waste we have to store permanently by 80%.

However, to use this spent fuel will still require some processing. This has been done for decades in other countries using a technique called PUREX, which has its roots in the U.S. from the 1940s – separating the plutonium out of the used fuel. The problem with PUREX is the risk that the process could be diverted to extract weapons-grade plutonium, a concern that prompted then-president Jimmy Carter to ban PUREX reprocessing in 1978. This spurred scientists at Argonne to search for a different, more efficient way to reprocess used fuel. Their brainchild is a technique called "pyroprocessing" which uses an electrical current to sift out the useful elements and does not separate out pure plutonium.

When the used fuel comes out of an LWR, it's in a hard ceramic form, and almost all of it is still just uranium – about 95% along with 1% other long-lived radioactive elements, called actinides. Both can be recycled as fuel. The remaining 4% is fission products, which are truly unusable.

Pyroprocessing begins by chopping the ceramic fuel into little pieces and converting it into metal. Then it's submerged in a vat of molten salts, and an electric current separates out the uranium and other reusable elements, which can be shaped back into fuel rods.

The truly useless fission products stay behind to be removed from the electro refiner and cast into stable glass discs. These leftovers do have to be put into permanent storage, but they revert back to the radioactivity of naturally occurring uranium in a few hundred years – far less than the thousands of years that untreated used fuel needs to be stored.

Bottom line: spent nuclear fuel is not WASTE. It should be considered a valuable resource…a strategic reserve similar to how the French and others seem to view it. Changing our perspective on spent fuel and what to do with it is vital to the future for not only our nuclear industry but for the challenge of zero-emissions.

HYDRO POWER – THE NEXT FRONTIER

Hydropower is by far the largest renewable source of energy worldwide, producing over twice as much energy as wind, and over four times as much as solar. In addition, pumped storage hydropower makes up over 90% of the world's total energy storage capacity.

Wudongde project construction at night

But in the U.S., we don't hear much about it. While the past few decades have seen wind and solar plummet in price and skyrocket in availability, domestic hydropower generation has remained about the same. Internationally, it's a different story. China has fueled its economic expansion by building hydropower, and it has long been central to China's power generation. Africa, India, and other countries in Asia and the Pacific are planning to develop this resource, as well.

China's first hydroelectric plant was completed in Yunnan province in 1912, but China didn't begin to ramp up hydropower until the 1980s, when their Three Gorges Project became part of a government program designed to support the country's economic development. The Three Gorges Hydropower Plant is the world's largest hydroelectric facility, with 22.5 GW of generation capacity – utilizing thirty-four power units.

Since 2020, China has more than quadrupled its hydroelectric power generation capacity and is the global leader in hydropower generation.

According to Global Data, a UK-based data analytics and consulting group, the country's cumulative installed capacity of its hydropower plants is just shy of 380 GW as of year-end 2021, growing at a rate of about 2.6% year-over-year. This enabled China to surpass the 1000 GW mark in 2021, accounting for 43.5% of China's total installed power generation capacity and providing ~28% of their electricity generation.

As part of their "West-to-East" Power Transmission Program, designed to move surplus electricity from western China to the more densely populated eastern part of the country, they have plans to use the abundant hydropower resources located in southwest China (***Guizhou, Yunnan, and Sichuan provinces***). These plans include four hydropower stations that will cascade from one to another and provide power to their major population and business centers, including Shanghai and Beijing.

The first (***by location***) of these four-hydropower stations is Wudongde, which ***(continued)***

became fully operational in the summer of 2021. It features twelve 850-MW units with a total capacity of 10.2 GW. It took about five-and-a-half years to build and set eight world records during its construction. Wudongde will cascade to Baihetan, a 16 GW hydropower plant - planned for operation later this year, and cascade to Xiluodu, a 14 GW hydropower plant – operating since 2013 - which cascades to Xiangjiaba, a 6.4 GW hydropower plant – operating since 2014. Together these four hydropower plants will provide 46.6 GW.

By comparison, the U.S. has 1450 hydropower plants and forty pumped-storage hydropower plants which account for 31.5% of our renewable electricity generation at a capacity of 103,000 MW - 6.3% of our electricity generation. Most of our hydropower is produced at large dams built by the federal government, with many of the largest hydropower dams located in the western United States. About half of the total U.S. utility-scale conventional hydroelectricity generation capacity is concentrated in Washington, California, and Oregon.

In the U.S., hydropower only grew at about 2 GW over the past decade, primarily as owners optimized and upgraded their existing plants. There have been few new hydro projects due to various concerns raised by environmental groups, and the rigorous process of acquiring approval and licensing from the dozens of different agencies. Malcolm Woolf, President, and CEO of the National Hydropower Association said, “the process takes longer than licensing a nuclear plant.”

Environmentalist say the reservoirs needed for a hydropower plant drastically change the landscape and the rivers they are built on, that the dams and reservoirs can reduce river flows, raise water temperature, degrade water quality, and cause sediment to build up, all having a negative impact on fish, birds, and other wildlife. Some recent studies have revealed that reservoirs can emit more carbon dioxide and methane than previously understood. And if that were not enough, the current climate-driven drought is making hydro a less reliable source of energy, as dams in the American West have lost a significant amount of their electricity generating capacity (***check out September’s newsletter article on pages 2-3***).

The average hydro power plant in the U.S. is over 60 years old – many of these will need to be relicensed soon. We could be facing a raft of license surrenders, at a time when we say we are ramping up our carbon-free generation. We have 90,000 dams in this country, most of which were built for flood control, for irrigation, for water storage, for recreation. Only 3% of those dams are actually used for generating power. Hydro has a big role to play in a 100% renewable future, so learning how to mitigate these challenges is a must. We can’t have a reliable grid without hydropower.

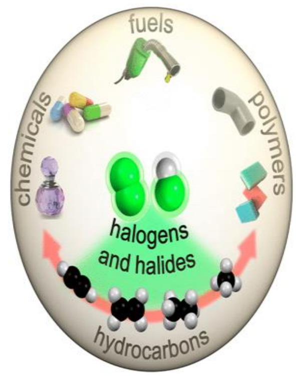
The Shasta Dam in California has been generating power since 1945

DID YOU KNOW?

Hurricane Ida took out 9 of these high voltage powerlines into New Orleans.

Hurricane Ida (***Category 4***) hit the New Orleans area on August 29, 2021 with maximum sustained winds of 150 mph, approximately 25 mph greater than Hurricane Katrina's maximum sustained winds? This resulted in the damage to 9 high voltage transmission lines feeding power to New Orleans. Entergy set out to rebuild the damaged transmission lines and harden others, and now some of these projects are finally complete. One major accomplishment is the 230kV Mississippi River powerline, crossing from Avondale to Harahan. This powerline segment has two 475-foot towers, one on either side of the river – now upgraded to withstand 175 mph winds, 25 mph higher winds than Hurricane Ida.

We can get energy from fossil fuels without producing carbon dioxide? It turns out that humanity's preferred method of making power and heat for the last million years - burning stuff - isn't the only way to extract energy from fossil fuels. When we burn these fuels - mixing hydrocarbons with oxygen - we produce heat, water, and carbon dioxide. But if you mix these hydrocarbons with halogens - the family of elements that includes iodine, bromine, chlorine - in the form of hydrogen halides, the halides only partially oxidize the fuel. This type of reaction produces heat, just like combustion, but instead of creating carbon dioxide, it produces simple carbon. This process has been around since the 1940's but was abandoned due to the costs and because back then , there was no real concern about producing CO_2. Today, CO_2 production is a major concern, but the **COST** is still a major issue. It requires about twice as much fuel to produce the same amount of energy as we can obtain from the combustion process. However, the halide – hydrocarbon process could become an alternative to carbon capture and sequestration. Besides being emission-free, the process has several other advantages; no flame, it produces char; we can still use the existing hydrocarbon infrastructure – (***wells, pipelines, refineries, etc***.); we can still produce the same ancillary chemicals that refineries make – (***methanol, olefins, ethanol, glycol, etc***.); It's easier to make hydrogen from natural gas using a hydrogen-halide process than the current process.

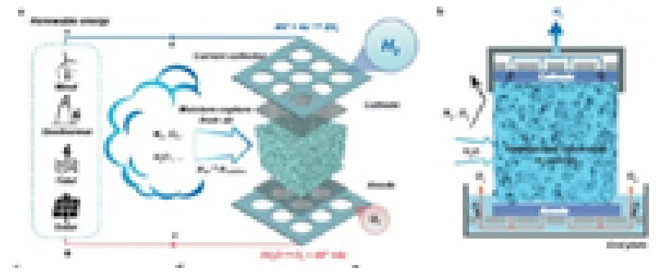


Halogen-Mediated Conversion of Hydrocarbons *has been around since the 40's but was abandoned due to costs. Burning stuff isn't the only way to extract energy from fossil fuels.*

Russia has a 30-year contract to supply China with a new LNG pipeline by 2025.

Russia and China have a 30-year contract for Russia to supply China with LNG (***liquid natural gas***) via a new pipeline they are constructing to be complete by 2025. Gazprom agreed to supply Chinese state energy major CNPC with 10 billion cubic meters of gas a year. First flow, which will connect Russia's Far East region with northeast China, is expected to start in two to three years. Russia already sends LNG to China via its Power of Siberia pipeline, which began supplying China LNG in 2019. It exported 16.5 billion cubic meters (***bcm***) of gas to China in 2021. The Power of Siberia pipeline network does not connect with Europe. With construction of this new pipeline, Russia plans to supply China with 38 bcm by pipelines by 2025. In addition, Russia has plans to pipe from its Far East island of Sakhalin across the Japan Sea to northeast China's Heilongjiang province, up to 10 bcm per year by 2026.

"GREEN HYDROGEN" FROM THE AIR



"Green hydrogen" is defined as hydrogen produced by splitting water into hydrogen and oxygen using renewable electricity, but it can also be accomplished with nuclear plant electricity. The production of hydrogen from nuclear plants is called "clean hydrogen."

In October 2021, the DOE (***Department of Energy***) awarded ~$40 million in funding to three nuclear utilities (***Arizona Public Service, Harbor Energy, and Xcel Energy***) to demonstrate they can produce "clean hydrogen" from nuclear power – providing a source of zero-carbon energy - an important economic product for nuclear plants beyond the production of electricity. These nuclear utilities are currently working to achieve DOE's goal to produce "clean hydrogen" at a cost of $1 per 1 kilogram of hydrogen.

One of the major issues for "green hydrogen" production centers around the geographic mismatch between renewables (***wind & solar***) and freshwater availability. This is not the case for nuclear plants as they are all located near a major water source.

Since water is the ultimate source for "green hydrogen" production, the issue of water availability may have been resolved. An international team of researchers just recently demonstrated the ability to produce "green hydrogen" directly from the air. They captured freshwater from the atmosphere using hygroscopic electrolytes and electrolysis powered by solar or wind with a current density up to 574 mA/cm^2. This prototype operated for twelve consecutive days with a stable performance at a Faradaic efficiency of around 95%. The direct air electrolysis (***DAE***) module can work with a relative humidity as low as 4%, overcoming water supply issues and producing green hydrogen sustainably with minimal impact to the environment. These researchers claim that these DAE modules can be easily scaled to provide hydrogen to remote, (***semi-***) arid, and scattered areas.

Hydrogen combustion is possibly the cleanest of all energy resources we have on the planet. The fuel is relatively easy to transport, and it can be burned anywhere, generating only water as the end product.

REPORT REVEALS SHUTDOWN OF INDIAN POINT WAS A BIG MISTAKE

Indian Point Nuclear Station was located in Buchanan, NY

The shutdown of Indian Point Nuclear Power Plant was a big mistake. It has resulted in a near-total dependence on fossil fuels to provide the needed electricity for New York's downstate region – 89% in 2021, up from 77% in 2020 when Indian Point was still operating. The end result for the consumer was an increase in cost – driving up the wholesale cost for electricity to $47.59 per megawatt-hour, nearly double the cost when Indian Point was still operating. In 2022, these costs are even higher as natural gas prices have continually increased along with oil-based fuels. The question for New York is whether or not they are going to continue making mistakes or can they learn from them?

Based on a recent report from the New York Independent System Operator (***NYISO***), the shutdown of Indian Point nuclear power plant (***pictured above***) was a big mistake.

It resulted in a near-total dependence on fossil fuels to supply electricity for New York's downstate region (***New York City, Lower Hudson Valley, and Long Island***). In 2021, 89% of the electricity supplied to downstate New York came from natural gas and oil, up from 77% for the previous year, when Indian Point's two reactors were still operating.

These figures demonstrate how much work is needed for New York to achieve its ambitious climate goals – to provide 70% of the state's electric demand with renewables by 2030 and achieve 100% zero emissions by 2040. Today, New York pro-nuclear advocates are urging the state to clear a path to allow nuclear power to play a larger role in the state's energy future – specifically SMRs (***small modular reactors***), while continuing the subsides beyond 2029 for the upstate nuclear plants (***Fitzpatrick, Ginna, and Nine Mile Point***) that are still operating.

"If we're serious about dealing with climate change, then we're going to need all the tools in the toolbox, which includes nuclear, not just now but in the future," said Keith Schue, an electrical engineer and a leader of *Nuclear New York*, a pro-nuclear group allied with James Hansen, a leading climate scientist. "We do believe that closing Indian Point was a mistake. (***continued***)

Indian Point Continued

But are we going to continue making mistakes or can we learn from them?”

The 2017 agreement to shutter Indian Point came when natural gas was cheap – in the $2 per MMBtu range. Today, natural gas prices are much higher, approaching five times that cost at its peak, which in turn has driven up the cost for electricity. In 2021, the average wholesale price of electricity in New York was $47.59 per megawatt hour, nearly double the cost when Indian Point was still operating. Energy resources that New York can access are decreasing each day. That trend is expected to worsen over the next several years, as the demand for electricity increases, and the peak usage is expected to shift from the summer to the winter – due to the need for heat and charging EVs (***electric vehicles***) overcoming the usage from air conditioners running around the clock in the summer.

Adding to this problem are the environmental regulations that will limit “Peaker” Plants (***oil and natural gas-fired plants used during peak usage timeframes***) from generating at their full capacity in the summer. These “Peaker” Plants located in the lower Hudson Valley, Long Island, and New York City will be limited to about half of their 3,300-megawatt capacity during the summer.

“The margins that we see on our system are shrinking,” NYISO president and chief executive officer Rich Dewey told reporters at a media briefing last month. The New York grid is in the most transformative moment in its history, as older generating plants are being shut down while the state introduces a slate of renewable energy projects – offshore wind on Long Island, wind power upstate, and battery energy storage for solar.

Schue said other nations have been adopting the next generation of nuclear energy generation into the mix. "We'd like to change that," Schue said. "We'd like to see New York step up to the plate. We've got the skills. We've got the spirit of innovation; we have the manpower."

“If we’re serious about dealing with climate change, then we’re going to need all the tools in the toolbox, which includes nuclear, not just now but in the future,” -Keith Schue, leader of *Nuclear New York*

THE "CLEAN ENERGY" POLICY YOU NEVER HEARD ABOUT

The so called "Inflation Reduction Act" (***IRA***) was really misnamed as it represents the largest single action that the U.S. has taken to address the climate crisis. The DOE (***Department of Energy***) claims the act will get the U.S. about 80% of the way to achieving the goal of a 50% emissions reduction by 2030 due to the long-term extension of clean energy tax incentives for renewables. They go on to claim that U.S. households will see $5 billion in electricity savings by the end of 2024 due to these clean electricity tax incentives.

However, the long-term economics of clean energy incentives alone will not achieve these outcomes because the clean energy transition has barriers that are tied to the regulatory and market structure of the electric power industry. The IRA provides a solution for these barriers with a little-known provision called the Energy Infrastructure Reinvestment (***EIR***) program – the "clean energy policy" you never heard about.

The EIR is a new loan program that can invest in energy communities that are willing to "retool, repower, repurpose, or replace energy infrastructure that has ceased operations, or reduce greenhouse gas emissions". This will be managed through the DOE's Loan Programs Office (***LPO***). They will be able to provide financing for up to $250 billion in loans to support the transition to cleaner energy, including the ability to refinance higher-cost debt and equity, saving ratepayers billions of dollars. They claim the EIR will support the low-carbon transition of a broad range of projects — any type of energy infrastructure related to electricity generation and transmission, as well as all fossil fuels and petrochemicals.

As utilities shift from coal-fired electricity production, the closure of coal-fired power plants could leave communities and workers behind, especially in rural or isolated areas that have few alternatives. These communities depend on these jobs, the tax revenue from the plant and workers for public services like schools, and economic development, which can all disappear when the coal plant is closed. In some cases, the utility may offer to transfer workers within the company or offer an early retirement package, but there is no comprehensive approach to support the workers and community through the transition. The EIR, however, offers these communities alternatives. One involves refinancing a retiring coal plant's remaining balance, as well as guaranteeing low-cost loans for replacement clean energy, environmental remediation costs, and redevelopment of the site into ***(continued)***

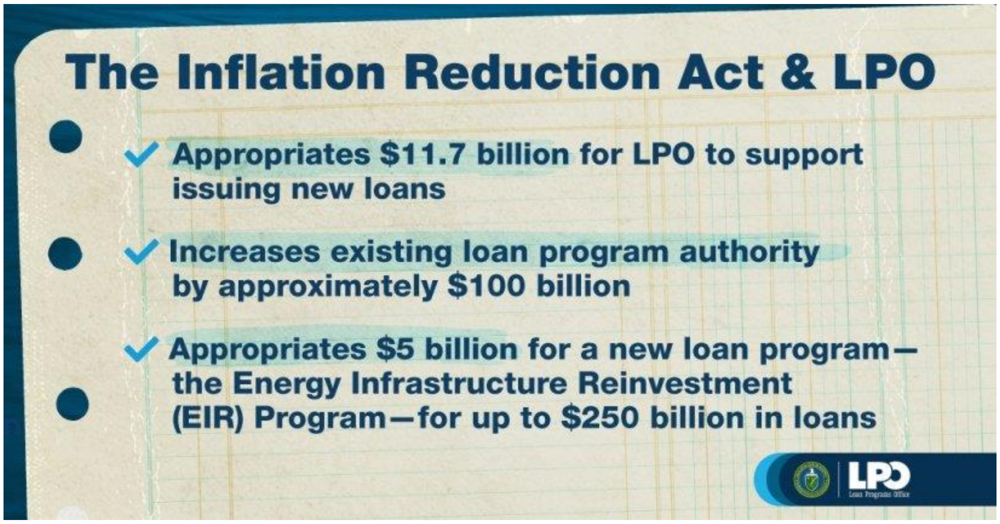
Clean Energy – Inflation Reduction Act Continued

productive other uses that would spur local economic opportunities. In this situation, the utility could apply for a low-interest loan, guaranteed by the LPO, to retire a fossil plant and pay off its plant balance, in a process similar to securitization - saving customers money, as the loan would be at a much lower interest rate than the utility's rate of return on the coal plant. It would also free up capital for the utility to reinvest in clean energy and transmission upgrades. Part (or all) of these clean energy and transmission upgrades could even be financed by the program, which would further lower costs.

In addition, language within the EIR requires utilities to pass on 100% of these financial benefits to ratepayers and their communities. The EIR also includes remediation of environmental damages - coal plants in particular leave behind toxic coal ash, which is often stored in ponds or landfills that can contaminate nearby groundwater and waterways. These coal ash sites are often located in disadvantaged communities, but the EIR offers low-cost financing to clean up these sites, improving the health outcomes of these communities and offering some short-term employment in cleaning up the site(s).

Finally, the EIR could be used for the economic revitalization of these coal communities where plants are retired. Some discussion is already underway of using these sites for natural gas plants or SMR's (***small modular reactor***). The EIR could provide low-cost financing for projects like these, removing one critical barrier in the redevelopment process.

Over the next decade, government spending on climate and "clean energy" policy will more than triple historical levels. This should spur some private spending on domestic manufacturing using "clean energy" and bring about a renewal in American manufacturing - providing additional opportunities for these previous coal communities



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