GridBright's Architecture for Long Interconnection Queues

Expediting the integration of vast amounts of renewable energy resources into the grid is a critical enabler for the Energy Transition

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GRIDBRIGHT®

Secure and Sustainable Grid Integration

EXECUTIVE SUMMARY

The urge to transition the global economy towards a low carbon energy future has resulted in unprecedented rise in investments in renewable energy resources, primarily **solar** and **wind**, which are now the cheapest source of electricity generation across the world. The resulting deluge of new solar plants and wind farms, both onshore and offshore, are creating problems of their own including supply-chain issues, skilled labor shortages as well as dealing with the inherent variability of renewables – which has resulted in massive increase in demand for energy storage. Additionally, connecting so many new renewable and storage plants to the high voltage transmission network has emerged as a serious **bottleneck** across the globe. Renewable and storage plants are useless unless their output can be fed into the transmission network and delivered to customers in major load centers while maintaining the grid's reliability.

As it turns out, connecting a renewable or storage plant often requires additional investments to the existing network or building new lines. The process of analyzing the impact of the new connection and allocating the costs and the benefits among multiple stakeholders is complex and time consuming.

This White Paper examines some of the challenges posed by the delays in connecting renewable and storage plants to the transmission network including:

- The sheer scale of renewable generation buildout;
- The challenges of integration renewable plants into the transmission network;
- The reasons behind the backlog – the so-called **interconnection queues**;
- The problems with getting access to **critical data** which is central to performing the analysis required to interconnect; and
- Issues with data security, confidentiality and standardization.

The White Paper offers a comprehensive **solution** to streamline the current laborious and time-consuming process of interconnecting new renewable plants to the transmission grid.

Once implemented, GridBright's proposed solution will greatly simplify and accelerate the process, reduce delays, eliminate uncertainties and lower costs to electricity customers. Moreover, it would make it possible to meet the goals of rapidly decarbonizing the US electricity grid in record time.

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INTRODUCTION

The global rush to transition towards a low carbon energy future is gaining momentum due to the urgency of averting the worst effects of climate change. This has resulted in massive investments in renewable energy resources, primarily **solar** and **wind**, which are now accepted as the cheapest source of electricity generation across the world.

The resulting deluge of new solar plants and wind farms have resulted in a host of new challenges including

- Supply-chain issues,
- Skilled labor shortages in installing, operating and maintaining new plants;
- Shortages of critical material and components; and
- Addressing the inherent variability of renewables – which has led to a massive increase in demand for **energy storage**. An increasing number of new renewable plants – especially solar ones – are now paired with storage for economic reasons[1].

While these issues are well known, another challenge, namely the **bottlenecks** constraining the integration of new renewable and storage plants to the high voltage transmission network has only recently surfaced as serious obstacle. The reason is simple: All plants, renewable or otherwise, must be able to feed their output into the transmission network to be profitable. As will be explained in this White Paper, the **transmission interconnection** is a complex problem because connecting a renewable or storage plant often requires

- Additional investments to the existing network – if it has spare transmission capacity; or
- Building new lines – if it does not.

In either case, detailed engineering analysis must be performed to determine the impact of the new interconnection to the network and – crucially – its costs and benefits. The process of analyzing the impact of the new connection and allocating the costs and the benefits among multiple stakeholders is complicated and time consuming. The regulators, both at the state and federal level, must review and approve the developer's "*application*" to interconnect before the project enters the "*queue*" to be connected to the network.

The complexity of the process is both *technical* and *procedural*:

[1] The value of solar generation tends to be low during sunny hours but high after the sun goes down at the end of the day – when many systems experience their peak demand. This makes pairing solar with battery storage highly attractive.

- The electrons injected into the network from the new plant follow **Kirchhoff's Law**, which means they impact the power flows on the existing network – sometime in unexpected ways – which usually impose costs and benefits on other stakeholders using the same network; and
- The regulators, both at state and federal level, require the applicant for the interconnection to follow established rules and procedures and comply with existing laws.

This White Paper examines the *technical* and *procedural* issues, both of which contribute to the long delays in connecting renewable and storage plants to the transmission network including:

- The sheer scale of renewable generation buildout;
- The challenges of integration renewable plants into the transmission network;
- The reasons behind the backlog – the so-called **interconnection queues**;
- The problems with getting access to **critical data** which is central to performing the analysis required to interconnect; and
- Issues with data security, confidentiality and standardization.

The White Paper's main contribution is to present GridBright 's comprehensive **solution** to streamline this laborious and time-consuming process.

As will be explained, once implemented, GridBright's solution will

- Simplify and accelerate the current process;
- Reduce delays;
- Eliminate uncertainties; and
- Lower costs to customers.

The result would significantly reduce one of the obstacles to meet the goal of rapidly decarbonizing the US electricity grid in record time.

THE TRANSITION TO RENEWABLES IS ACCELERATING

The transition to a low carbon future requires vast amounts of renewable energy resources to be added to the existing electricity generation mix over the next few decades. The scale and the speed of this transition is unprecedented in the US and across the globe driven by the urgency of avoiding the worst impacts of climate change.

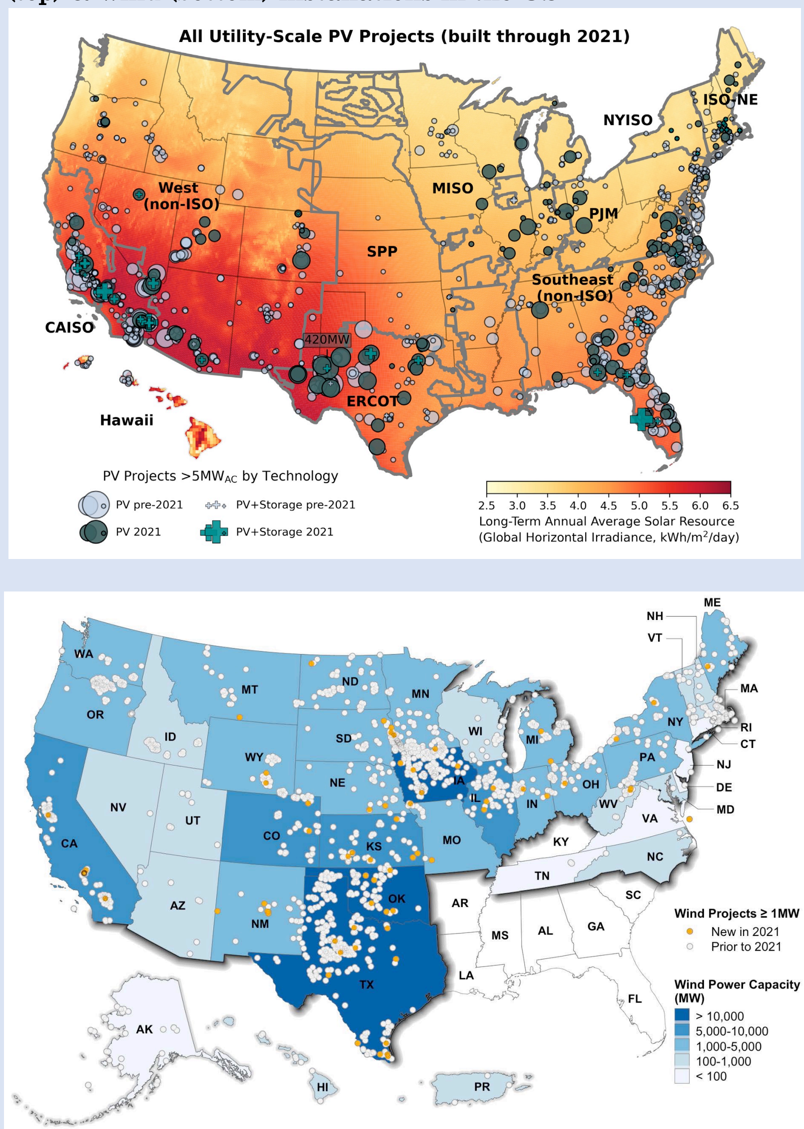
The **Biden Administration** is aiming for renewables to supply 80% of the demand to be supplied by renewables over the next decade. The passage of the **Inflation Reduction Act**[2] (IRA) in 2022 further accelerated the pace of investments in renewable generation plants, which are increasingly paired with storage. As described in **Deep Dive 1**, renewables are the fastest growing resource added to the US electricity generation mix.

[2] https://www.congress.gov/bill/117th-congress/house-bill/5376/text

Deep Dive 1 - Renewables to dominate the US electricity grid

The transition to a low carbon future is driven by a number of factors including targets set by the **Renewable Portfolio Standards** (RPS) and/or **carbon neutrality** goals in states like **California** and **Hawaii**. Furthermore, since solar and wind are now the cheapest sources of electricity generation, they are being added at rapid pace across the country including in states such as **Texas** and **Oklahoma** purely for *economic*, not ideological or environmental, reasons.

Fig 1
Utility-scale solar (top) & wind (bottom) installations in the US[3]



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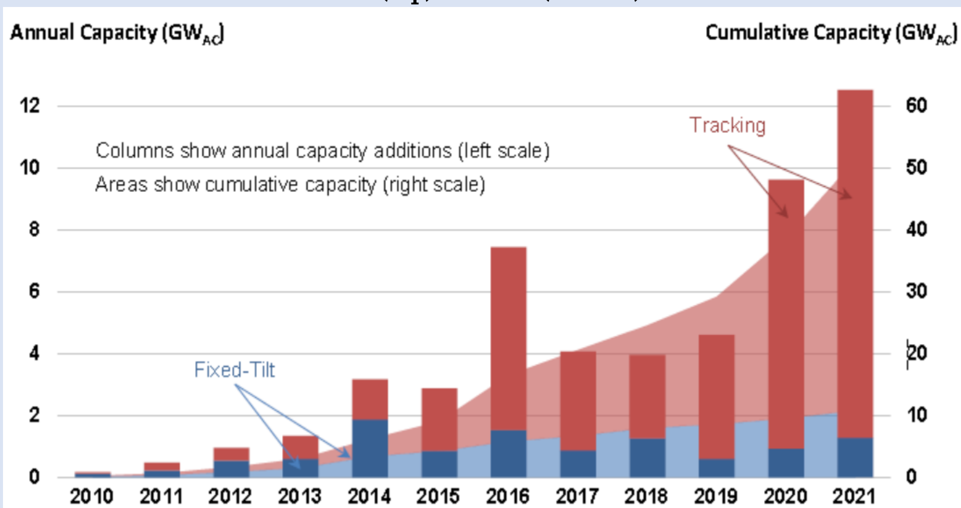
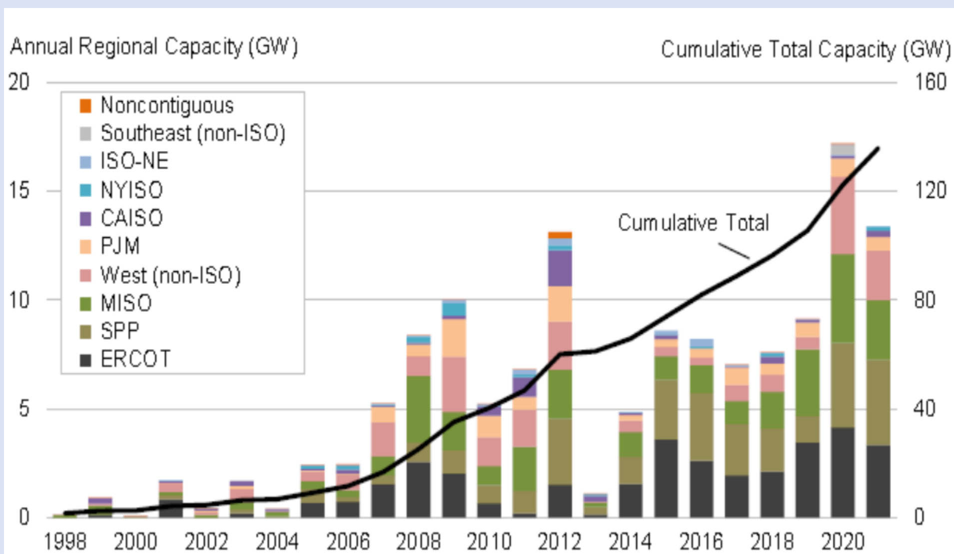
[3] Top map from the Utility-scale solar, 2022 edition, Lawrence Berkeley National Laboratory (LBL) page 10 at https://eta-publications.lbl.gov/sites/default/files/utility_scale_solar_2022_edition_slides.pdf and bottom map from Land-based wind project report, 2022 edition, LBL, Aug 2022, page 10 at https://emp.lbl.gov/sites/default/files/2022_land_based_wind_market_report_ppt.pdf

While vast amounts of solar and wind have been added in the recent past, the **Energy Information Administration** (EIA) projects that renewables will be the greatest source of *new* capacity additions in the US for the foreseeable future. Many renewable plants, especially solar, are increasingly paired with storage which means a fast growth rate for energy storage.

Fig 2
Cumulative and annual additions of solar (top) & wind (bottom) in the US[4]

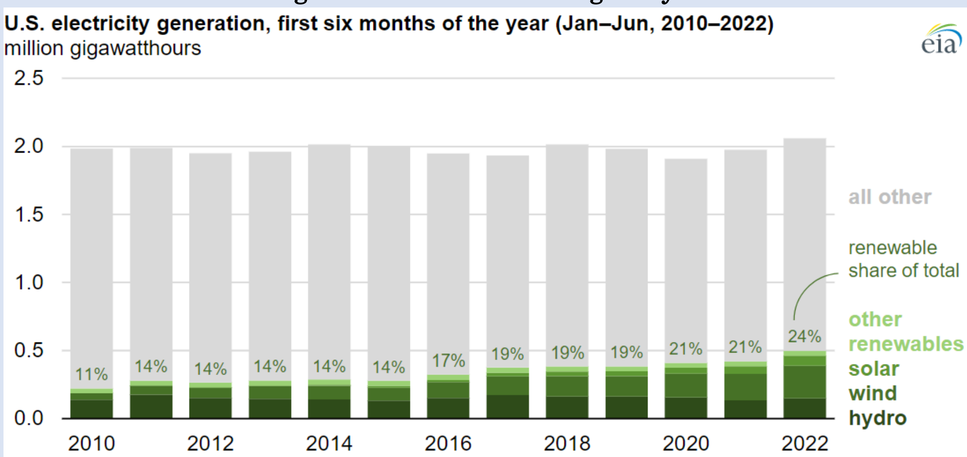




The Biden Administration is aiming for renewables to supply some 80% of the US electricity generation by 2030 from roughly 24% at the end of 2022.

[4] Utility-scale solar, 2022 edition, LBL, page 13 at https://eta-publications.lbl.gov/sites/default/files/utility_scale_solar_2022_edition_slides.pdf

Fig 3
The Biden Administration is aiming for an 80% renewable grid by 2030



As illustrated in Fig 1, renewable plants are usually located where the land is cheap and the wind or solar resource is plentiful – typically hundreds of miles away from major load centers and/or transmission lines.

Table 1
Wind as percentage of demand in selected states

Top 5 states in installed capacity (left) and as % of total in-state generation (right)

Installed capacity, GW			Wind as% of total generation	
Texas	36 GW		**Iowa**	55%
Iowa	12		**So. Dakota**	52
Oklahoma	11		**Kansas**	45
Kansas	8		**Oklahoma**	41
Illinois	7		**N. Dakota**	34
US total	136 GW			9%

The prevalence of both wind and solar has risen to levels where they provide a significant percentage of demand in some states as shown for **wind** in Table 1 for the Great Plains[5]. Similarly, solar generation now overwhelms the grid in states such as **California** during cool sunny months of the year where occasionally solar generation exceeds total demand during mid-day hours. ■

CHALLENGES OF RENEWABLE INTEGRATION

The rush to add massive amounts of renewable and storage capacity over such a short period of time has led to multiple challenges, bottlenecks and obstacles including significant delays in interconnecting utility-scale renewable plants to the transmission network. This is critical because without an approved interconnection generators cannot sell their output to the markets with significant financial implications for the developers, investors as well as the customers.

[5] Data from Land-based wind market report, 2022 edition, Aug 2022, LBL, page 11 at https://emp.lbl.gov/sites/default/files/2022_land_based_wind_market_report_ppt.pdf

As explained in **Deep Dive 2**, getting approval to interconnect the new plants to the transmission network is a complex and labor-intensive process and among the reasons for the **long interconnection queues**.

Deep Dive 2 - Getting approval to interconnect is time consuming and costly[6]

Before a new generator, renewable or otherwise, can sell its output in the market it must get approval for a grid **Point of Interconnection** or POI. This requires an **Interconnection Capacity Analysis** or ICA, the purpose of which is to determine the impact of the new plant on the existing network, power flows and prices. In many cases, the existing transmission network may not have adequate capacity to handle the new load and must be upgraded. In some cases, new transmission lines must be built to handle the new generation. To perform the ICA, detailed engineering studies must be performed, which require access to commercially sensitive data from multiple sources.

As an example, to obtain a POI in California requires:

- Obtaining the base case power flow data from the **Western Electric Coordinating Council** (WECC) as well the **California Independent System Operator** (CAISO) under **Non-disclosure Agreements** (NDAs) subject to strict privacy and cyber security requirements set by the **North American Electric Reliability Corp.** (NERC) and the **Federal Energy Regulatory Commission** (FERC) compliance rules;
- Once the necessary data[7] is acquired, complex engineering analysis is needed to determine the available hosting capacity of the existing transmission system and the impact of the renewable plant on future congestions through power flow injection studies, estimating potential future revenue from the renewable project through production cost simulation modeling; assessing qualification to provide Resource Adequacy (RA) Capacity, and estimating interconnection costs that should be assigned to the project as determined by the analysis; and
- Repeating the analysis under different scenarios of future loads and prices before approving the POI.

Similar steps are required in other regions of the country. Currently,

- The first step is a highly manual and bureaucratic process typically accompanied by significant delays and cyber security risks as data must be transferred among multiple stakeholders;
- The second step can benefit from commercially available software products which can automate some tasks but the process requires professionals with transmission planning experience, which are hard to find; and
- The final step requires even more professional expertise, energy market experience and significant labor.

The net result is that the overall analysis – the ICA process – is costly and time consuming. As will be further explained, historically the process took typically 4-6 months costing $100,000 or more. Both the time and the costs have significantly increased recently. ■

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[6] Further details and insights may be found at GridBright's website at https://www.gridbright.com/insights/ and concept paper AI-driven Renewable Interconnection Siting (AIRIS).

[7] As will be described later, the data is frequently in non-standardized form, which requires additional effort before it can be used in the analysis.

The interconnection analysis described in Deep Dive 2, however, is not the only reason for the long **interconnection queues**. After the **Interconnection Capacity Analysis** or ICA is completed and approval for a grid **Point of Interconnection** or POI has been granted, the project must wait in the *queue* before it can sell its generation to the market and ultimate customers.

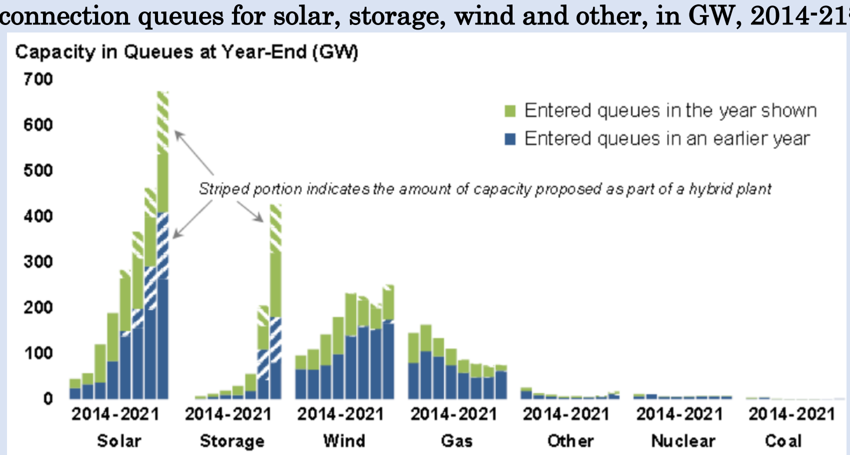
Deep Dive 3 describes the current scale of the interconnection queues followed by an examination of several other factors that also contribute to the delays. As already mentioned, the problem is complex for both technical and procedural reasons. Regardless of the causes, the backlog results in construction delays, project financing problems while adding to uncertainties of when the project can begin operations.

Deep Dive 3 - Why the long interconnection queues

With the increasing pressure to decarbonize the US grid, vast number of renewable plants, mostly solar and wind, some paired with storage, are being planned, financed, and developed across the country. Many, however, are unable to commence operation because of bottlenecks in connecting to the transmission network. These are referred to as **interconnection queues**.

Fig 4 shows the dramatic rise of the interconnection queues for wind, storage, wind and other resources during the period 2014-2021 before the passage of the **Inflation Reduction Act** (IRA) in 2022. The expectation is that the queues will get longer in the next few years as more renewable projects join the existing queues.

Fig 4
The rise of interconnection queues for solar, storage, wind and other, in GW, 2014-21[8]



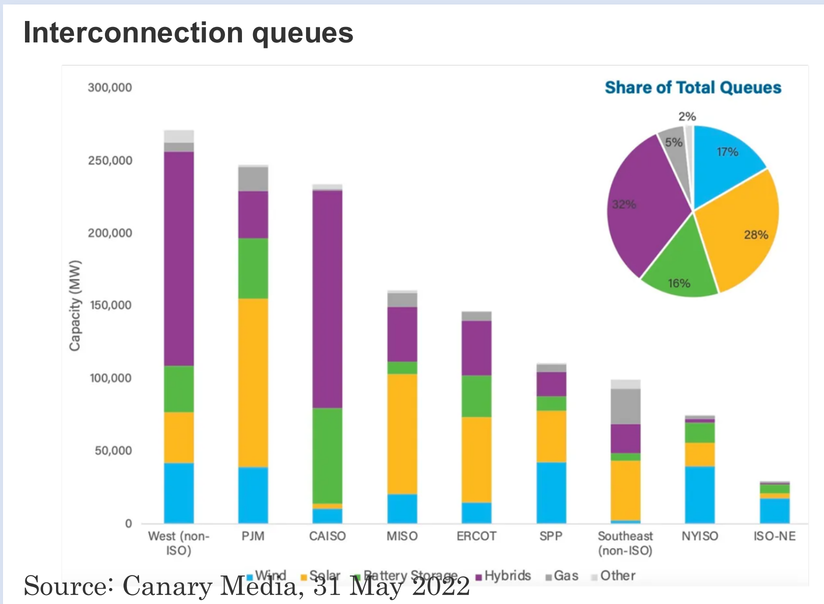
By some estimates, there are currently an estimated 1,300 GW of solar, wind, battery storage and conventional projects awaiting interconnection — technically enough to supply roughly 80% of the country's electricity demand. Fig 5 from the **American Clean Power Association** shows the mix of resources queued up in different parts of the country.

[8] Utility-scale solar, 2022 edition, LBL, page 55 at https://eta-publications.lbl.gov/sites/default/files/utility_scale_solar_2022_edition_slides.pdf

A report by the **Lawrence Berkeley National Laboratory** (LBL) put the numbers even higher[9] but notes that not all the projects in the pipeline will actually come online partly because of the time it takes and the rising costs of getting to an interconnection agreement.

According to the LBL report, the waiting time in the queue has grown from an average of 1.5 years to more than 3.5 years while the costs of grid upgrades have soared. Five years ago, the average cost of upgrades needed to connect a new project to the grid accounted for less than 10% of a typical project's overall price tag. The cost of typical interconnection has grown to as much as 50-100% of the overall project cost[10].

Fig 5[11]
Interconnection queues



Source: Canary Media, 31 May 2022

A more recent report by the **Lawrence Berkeley National Laboratory** (LBL) examined the interconnection queues in the **PJM Interconnection**, the biggest organized electricity market in North America[12]. It reported that at the end of 2021, PJM had 259 GW of generation and storage capacity actively seeking grid interconnection. The data for 2022 is likely to show further additions to the existing queue as new projects are developed to take advantage of the **Inflation Reduction Act** (IRA) before it expires. The latest LBL report noted that:

> "Capacity in PJM's queue is dominated by solar (116 GW) and, to a lesser extent, standalone battery storage (42 GW), solar-battery hybrids (32 GW), and wind (39 GW). PJM's dataset also contains data for projects no longer seeking interconnection, both those that are in service (79 GW) and those whose applications have been withdrawn (432 GW)."

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[9] https://newscenter.lbl.gov/2022/04/13/record-amounts-of-zero-carbon-electricity-generation-and-storage-now-seeking-grid-interconnection/

[10] https://www.canarymedia.com/articles/transmission/fixing-the-us-power-grid-a-challenge-for-2023-and-beyond

[11] Visual from Canary Media, 31 May 2022, at https://www.canarymedia.com/articles/policy-regulation/here-are-ways-to-connect-clean-energy-projects-to-the-grid-more-quickly

[12] https://emp.lbl.gov/interconnection_costs

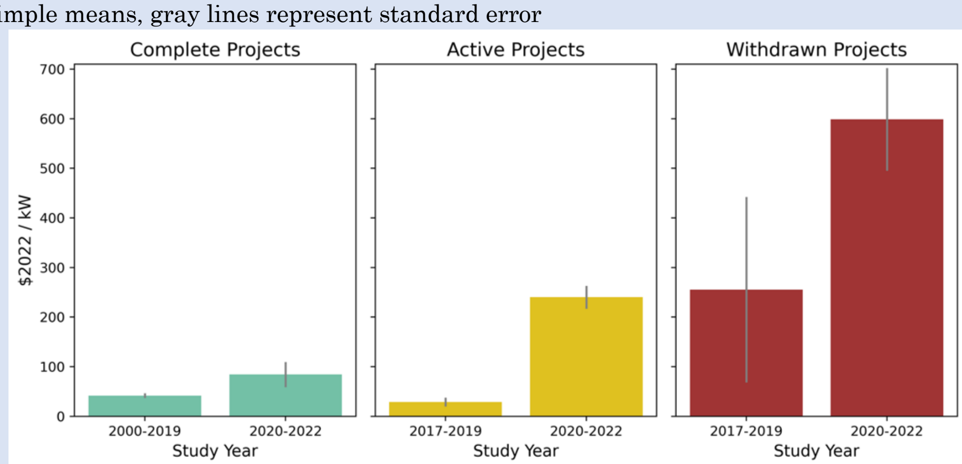
"PJM's queue has ballooned in recent years, with 2021's active queue increasing by 240% compared to year-end 2019. The capacity associated with interconnection requests is nearly twice as large as PJM's peak load in recent years (~155 GW)."

The overall assessment of the LBL study is rather alarming[13]. It said, "**For projects with completed studies and plants now in service, costs have doubled. For active projects still in the queue, estimated costs have grown eightfold since 2019."**

The LBL report concluded that:

"This explosive growth of interconnection requests along with lengthy study timelines and high project withdrawal rates motivated PJM to reform its interconnection process in 2022. PJM adopted a ***first-ready, first-served*** cluster study approach and increased study deposits that are at risk when projects withdraw."

Fig 6
PJM Interconnection costs over time by request status[14]
Bars show simple means, gray lines represent standard error



The LBL concluded that the main driver behind these increases has been broader network upgrade costs and noted that average costs for upgrades beyond the interconnecting substation have risen sharply since 2019 to

- $71/kW for complete projects;
- $227/kW for active projects; and
- $563/kW for withdrawn projects.

The data for 2022 was not available for the study but is expected to show a worsening situation as further analysis is done.

[13] The PJM brief is the second in a series analyzing interconnection costs in wholesale electricity markets, with an October 2022 study containing similar findings about MISO. LBL will publish analyses of NYISO, ISO-NE, and SPP later in 2023.

[14] Interconnection cost analysis in PJM territory, Jan 2023, LBL at https://eta-publications.lbl.gov/sites/default/files/berkeley_lab_2023.1.12-_pjm_interconnection_costs.pdf

What explains such long queues? It is a complex story but basically the problem boils down to the fact that currently in the US not a single federal or state agency is in charge of transmission planning or permitting process. At the same time, tensions between the federal regulator, the **Federal Energy Regulatory Commission** (FERC), state regulators and multiple local agencies makes it difficult to get quick approvals. Since transmission lines typically cross state boundaries, it is not clear whose interests, views or priorities should prevail especially when the benefits may accrue to some while the costs, including environmental ones, are borne by others.

On top of this, there are multiple stakeholders – competing generators, developers, investors, regulated utilities, transmission owners/operators, wholesale market operators, customers, etc. – with opposing interests, views and incentives. Add several layers of bureaucracy at the federal, state and local levels and what you get are uncertainties and delays in obtaining the necessary approvals. Opposition from the environmental groups and others opposed to the proposed projects further adds to the delays. Even after approval is granted, the project joins many others in long **transmission interconnection queues** which ultimately lead to higher costs to customers.

The passage of the **Inflation Reduction Act** (IRA) in 2022 has exasperated the problem by further increasing the number, scale and pace of investments in renewable generation plants. Since the output of both wind and solar plants is inherently variable, man y, especially solar plants, are increasingly paired with storage facilities, making the queues even longer. ■

ADDRESSING THE LONG INTERCONNECTION QUEUES

Key stakeholders including FERC, ISO/RTOs, renewable developers, investors, transmission owners, utilities and consumer groups are increasingly concerned about the long interconnection queues which delay the integration of utility-scale renewable plants into the grid, creating uncertainties while resulting in higher costs to electricity consumers.

The problem has been known for a while but has simply gotten far too big even for the slow moving bureaucracies and regulators to ignore. The optics of having so much clean, sustainable and low cost renewable generation waiting to be integrated into the transmission network is not good for anyone.

- The policymakers at both federal and state level are frustrated to see the delays in meeting decarbonization goals because the new capacity cannot be utilized;
- Renewable developers and investors are frustrated because they cannot operate their plants and make money;
- Customers and the advocates are frustrated because they are deprived on access to low-cost low-carbon generation and lower electricity bills; and
- Environmentalists are appalled that precious time is being wasted to address climate change and reduce US carbon emissions.

For its part, the **Federal Energy Regulatory Commission** (FERC) has issued a number of **Notices of Proposed Rulemaking** (NOPRs) in the past couple of years to address the problem but progress has been frustratingly slow – certainly too slow to resolve the massive backlog of applications by renewable generators and storage projects to connect to the grid in a timely and predictable fashion. **Deep Dive 4** examines some of the recent steps considered by FERC to streamline the process.

Deep Dive 4 - FERC's proposals: Necessary but not sufficient

The **Federal Energy Regulatory Commission** (FERC) is the central player both in creating and in attempting to address the transmission interconnection queues. To understand its role and what it is trying to do it is helpful to review the agency's role in several seminal decisions issued in the recent past.

- In 1996, FERC issued **Order No. 888**[15] and the accompanying *pro forma* **Open Access Transmission Tariff** (OATT), setting forth certain minimum requirements for transmission planning. At its core OATT obliged utilities or transmission owners to treat other parties' transactions in the same manner they treated their own;
- In 2007, the Commission issued **Order No. 890**[16] to remedy flaws in the *pro forma* OATT specifically requiring that each transmission provider's local transmission planning process satisfy 9 transmission planning principles;
- In 2011, the Commission issued **Order No. 1000**[17] to build on the transmission planning requirements of Order No. 890 including a package of reforms to ensure that the transmission planning and cost allocation mechanisms embodied in the *pro forma* OATT were adequate to support the development of more efficient or cost-effective transmission facilities[18];
- In 2004 FERC issued **Order No. 2003**[19] in which it recognized a need for a single set of interconnection procedures for jurisdictional transmission providers and a single, uniformly applicable interconnection agreement for large generators.

In Order No. 2003, the Commission also retained a distinction between

- Interconnection facilities, which are located between the interconnection customer's generating facility; and
- The transmission provider's transmission system, and network upgrades.

This distinction is important because the determination of which entity is ultimately responsible for the cost of a facility can depend on whether that facility is an **interconnection facility** or an **interconnection-related network upgrade**.

More recently, the commission has acknowledged that generator interconnection is a "critical component of open access transmission service and thus is subject to the requirement that utilities offer comparable service under the OATT.

The Commission has also determined that, because of the inefficiency of addressing generator interconnection issues on a case-by-case basis, it was appropriate to establish a standard set of generator interconnection procedures to "minimize opportunities for undue discrimination and expedite the development of new generation.

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[15] Refer to https://energyknowledgebase.com/topics/ferc-order-888.asp
[16] https://www.ferc.gov/sites/default/files/2020-06/OrderNo.890.pdf
[17] Refer to https://www.ferc.gov/electric-transmission/order-no-1000-transmission-planning-and-cost-allocation
[18] Successive FERC Orders led to the creation of Open Access Technology International, Inc. (OATI), which provides many of the services required by FERC. For further details refer to https://www.oati.com
[19] Refer to https://www.ferc.gov/sites/default/files/2020-04/order2003-a.pdf

To this end, the Commission adopted the *pro forma* **Large Generator Interconnection Procedures**[20] (LGIP) and ***pro forma*** **Large Generator Interconnection Agreement**[21] (LGIA).

To understand the **interconnection queues**, it is helpful to understand the current cumbersome FERC-approved process. To initiate a **generator interconnection process** set forth in **Order No. 2003** the interconnection customer submits:

- An **interconnection request** associated with its proposed generating facility that includes preliminary site documentation;
- Certain technical information about the proposed generating facility, and the expected in-service date along with a deposit;
- The **transmission provider** uses this information to determine the **interconnection facilities** and **interconnection-related network upgrades** necessary to accommodate the interconnection request and their associated costs;
- Only after the transmission provider has determined that the interconnection request is complete, the interconnection request will enter the **interconnection queue** along with other pending requests, and the transmission provider will assign the request a **queue position** based on the date of the receipt of the application.

The assigned **queue position** will determine the order in which the transmission provider will perform three phases of interconnection studies for the interconnection request, namely

- A feasibility study;
- A system impact study; and
- A facilities study,

all of which are necessary to determine the interconnection facilities and interconnection-related network upgrades needed to accommodate the interconnection request and the applicant's cost responsibility for these facilities.

At the completion of the facilities study – the last of the 3 steps highlighted above – the transmission provider issues a **report**, which includes

- A **best estimate of the costs of the requested interconnection**; and
- A **draft generator interconnection agreement** to the applicant.

Following negotiations, if the applicant wishes to proceed, the interconnection customer enters into a **generator interconnection agreement** with the **transmission provider** or requests that the transmission provider file an unexecuted agreement with the Commission.

As noted above, **Order No. 1000's cost allocation reforms** require each transmission provider to participate in a **regional transmission planning process** that features a regional cost allocation method or methods.

The Commission also required that such regional cost allocation methods satisfy 6 **regional cost allocation principles**, including the principle that the cost of transmission facilities must be allocated to those in the transmission planning region that benefit from the facilities in a manner that is roughly commensurate with estimated benefits.

[20] Refer to https://www.ferc.gov/sites/default/files/2020-04/LGIP-procedures_0.pdf
[21] Refer to https://www.ferc.gov/sites/default/files/2020-04/LGIA-agreement.pdf

It must be noted that new transmission facilities often have a **development lead time** that exceeds the interconnection timing needs of those interconnection customers already in the queue. It appears that these types of transmission facilities may not currently be planned and built in advance to meet the needs of anticipated future generation and as a result, interconnection customers are assigned the costs to construct large, high-voltage transmission facilities.

Moreover, the current case-by-case generator interconnection process may not adequately consider whether it may be more efficient or cost-effective to consider the interconnection-related network upgrades needed for multiple anticipated future generators that are not in the same cluster or are not yet in the interconnection queue in areas that have abundant wind or solar attributes that could support **multiple future generators**.

A transmission provider may identify transmission facilities that could facilitate both the interconnection of new generation as well as address other identified transmission system needs – such as mitigating a reliability violation or reducing congestion – at a lower total cost than pursuing two separate transmission projects through the generator interconnection and regional transmission planning and cost allocation processes.

Without co-optimization of the two processes, however, there appears to be **no system in place to jointly assess the benefits and allocate the costs of transmission facilities that yield benefits to both system loads and new generation**.

Recognizing many of these and other issues, the Commission says,

> "We understand that a contributing factor to the interconnection queue backlog is a tendency by interconnection customers to submit multiple interconnection requests at different points of interconnection, with the intention of discovering the lowest cost site for a project (from an interconnection perspective), and then withdrawing higher-cost projects from the queue later in the process. This tendency can require numerous restudies and reallocation of interconnection-related network upgrade costs, compounding the uncertainty surrounding the amount of interconnection- related network upgrade costs that will be attributable to viable projects as the queue progresses."

Another possible reform to the current crediting policy is to consider the establishment of a **non-refundable fee** to be charged for submitting an interconnection request and that is not reimbursable through transmission service credits.

Specifically, in its latest NOPRs, FERC proposes to:

- Implement a first-ready, first-served cluster study process;
- Increase the speed of interconnection queue processing; and
- Incorporate technological advancements into the interconnection process. ■

These reforms, while helpful, are *not* expected to address the immediate backlog, nor speed up the expected deluge of additional applications significantly. In other words, while necessary they are not sufficient to solve the long interconnection queues.

Many in the industry believe that the current cumbersome and bureaucratic process is simply no longer fit for purpose given the sheer number of new interconnection applications already in the queues with many more expected. FERC is trying to address the problem with its proposed reforms. Its proposed **cluster approach,** where a number of projects in the same geographical area can apply and get approved as a *cluster* at the same time, for example, is a welcomed improvement. This will allow the cluster to be analyzed at the same time and share the costs of network upgrades.

Another proposal is to increase the application fee charged to enter the queue. This would reduce speculative projects from joining the queue. Other proposals, such as giving priority to projects that are in advanced stage of development and/or ready to commence operation, are also helpful.

Other proposals include changing the order of doing things. Rather than adding transmission piece by piece to connect new generation, why not build lots of transmission capacity when and where it will be needed to be utilized as new renewable plants are built. This approached – successfully applied in ERCOT to develop its vast wind resources in areas far from the load centers – has been recognized as one way to speed up the transmission interconnection process by FERC.

But those involved generally realize that the interconnection delays have less to do with getting regulatory approval and addressing environmental issues and more to do with the technical engineering analysis to determine the new infrastructure costs required to connect new generation to the existing transmission network and allocating those costs which accrue unevenly among the stakeholders. The ultimate hurdle, of course, is the time it takes to do the actual build out, namely the **construction time**.

Other experts believe that the traditional approach of adding more transmission to accommodate more generation – which worked in the past when there were few large central plants usually paired with the required transmission upgrades – may not be sustainable given the surge of new applications, both large and small. Some are proposing new approaches such as developing semi-autonomous **micro-grids** serving local communities or regions which are connected to and served by a super **macro-grid**.

DATA ACCESS IS AN OBSTACLE

The preceding explained the cumbersome and bureaucratic process to apply and get a **queue position** for the developer of a renewable plant or storage project, which means joining hundreds of others waiting to be connected to the transmission network.

As already described above, the engineering analysis that is required before the interconnection application can be approved is inherently complex. Making matters worse is the fact that performing the analysis requires lot of detailed data about the existing network to which the new plant will be exporting its output. This, as further explained in **Deep Dive 5** and in subsequent sections of this White Paper, requires, among other things

- Access to highly sensitive data, which in some cases simply does not currently exist;

- Which is not in usually standardized form or granularity that is required;
- Which is usually "*owned*" by multiple stakeholders who are not necessarily eager to share it; and
- Which must be treated/transferred with extreme care and confidentiality due to security concerns.

For these and other reasons permission must be obtained from multiple parties to obtain the data. Given the sensitivity of the data and concerns about confidentially and privacy, once permission is granted the data is provided with many strings attached, including **non-disclosure agreements** (NDAs) as well as a legally binding "*for purpose*" clause, which restricts its use for a specific purpose and single time. This means that the same data cannot be used to perform analysis for another application, which means that if the applicant has multiple projects in the same vicinity, it must repeat the cumbersome process of requesting the data multiples of times.

Deep Dive 5 - The data access problem

The preceding described the multiple steps required for the transmission interconnection provider to determine if the applicant meets the requirements to be placed in the interconnection queue. At the core of this process is the analysis by the transmission provider which includes

- A feasibility study;
- A system impact study; and
- A facilities study.

This analysis is necessary to determine two critical pieces of information namely,

- The required interconnection facilities; and
- The required interconnection-related network upgrades

both of which are needed to approve the request and determine the applicant's cost responsibility for the required facilities. The analysis typically concludes with

- An **estimate of the costs of the requested interconnection**; and
- A **draft generator interconnection agreement**.

Needless to say, performing the necessary analysis is data-intensive and complex. The required data, central to determine the costs of getting interconnected to a given point in the transmission grid is frequently problematic because:

- It may not exist in whole or in the form and format required for the analysis;
- It may be incomplete, out of date, or inaccurate; and
- Even if it exists, it is frequently owned by multiple stakeholders who may not necessarily wish to share it due to confidentiality concerns, privacy issues or for commercial reasons.

In most instances, to analyze the interconnection application requires sensitive data from and/or the participation, cooperation and/or consent of multiple parties including

- The **regional transmission organization** (RTO) or **independent system operator** (ISO) if the generation plant is within the footprint of such an organized market;

- The interconnection provider which may be a regulated vertically-integrated utility, a transmission-only-utility or a federal or municipal entity;
- Regional coordinating organizations such as the **Western Electricity Coordination Council** (WECC) or similar entities in other parts of the US;
- The **North American Electric Reliability Corp** (NERC), which is responsible for the grid's reliability;
- Local and regional landowners, tribes, communities, or cities traversed by the proposed transmission line and/or transmission upgrades; and
- Other stakeholders who may be impacted by the proposed transmission line or required upgrades include environmental groups.

The unavailability of data, privacy, confidentiality, and the conflicting interests of various stakeholders make it difficult to obtain the commercially sensitive required data in a timely fashion. Moreover, the multiple stakeholders typically have differing views, conflicting interests, and motivations. Not all stand to gain from the generating plant, the transmission upgrades or new lines that may be required. All these factors combine to slow the process and make the task of obtaining the necessary data to perform the required analysis more complicated. ■

INTERCONNECTION NEEDS DATA SECURITY, STANDARDIZATION AND ACCESS

Among the many hurdles to get a new renewable plant or storage project connected to the grid is the mandatory engineering analysis that is required to determine the impact of the new facility to the power flows on the existing transmission network. This analysis is required to determine what additions and/or upgrades to the existing infrastructure are needed, how much it will cost, what benefits accrue, and to whom the costs and benefits must be appropriated. Since electrons follow **Kirchhoff's law**, adding generation or transmission affects power flows across the entire network, sometimes with unexpected consequences. Not all existing stakeholders necessarily gain from such new additions with the distribution of the costs and benefits unevenly distributed across the network.

Performing the analysis is a complex but necessary step required by FERC as well as other stakeholders. And the analysis critically depends on getting quick access to accurate, complete and up-to-date data on the existing infrastructure, power flows, prices and other physical characteristics of the transmission network to which the new facility is to be connected. Access to data, however, is complicated because:

- Of legitimate concerns about the **security** and confidentiality of the highly sensitive data that frequently must be obtained from multiple stakeholders;
- The fact that the data, even when it exists, is not necessarily in a **standardized** or usable form for the analysis;
- Additionally, there is currently no secure centralized warehouse, **database** or repository where standardized data is stored and can be easily accessed by those who need it; and

- Finally, presently there is no user-friendly software or tools that **automate** and expedite the labor-intensive data gathering and crunching tasks further exacerbating the delays.

These inter-related issues go beyond simply getting *access* to the data. Addressing each requires effort and new tools as further described in **Deep Dive 6**.

Deep Dive 6 - Data security, standardization, warehousing and automation

Having access to the required data is central to the process of performing the analysis before getting approval to connect to the transmission network – and among the reasons the process currently takes so long. But the *data access issue* is clearly more complex and nuanced as explained below.

> First is **data security**, which means its transmission from one party to another must be secure. This requires establishing appropriate protocols that safeguards the transmission of sensitive data among multiple parties.

Current data communication protocols rely on obsolete technologies such as **Secure Socket Layer** or SSL, which is not appropriate for transferring sensitive information such as sensitive transmission-related data. Other industries including banking, healthcare, and defense have already migrated to more secure **End-to-End Encryption** (E2EE) to maintain data security. The time has arrived for the utility industry must do the same.

Developed through a recent **DOE ARPA-E** sponsored research & development project, **GridBright** has proposed the creation of a **Secure Grid Data Exchange** as a new standard for transmitting commercially sensitive data over untrusted links including clouds[22].Once implemented, this scheme would reduce risk, ensure compliance with regulatory requirements, and enhance industry interoperability across various stakeholders who need to share the same sensitive data. All grid-related data must, of course, meet the **Critical Infrastructure Protection** (CIP) standards imposed by NERC[23].

> Second, **data standardization**, another major source of delays in the analysis process, refers to the problem of having data in different formats and different granularity, which means someone has to manually "clean it up" and put it into usable and standardized form before it can be used.

No data, however, can be shared among the stakeholders without **non-disclosure agreements** (NDAs). Working with several ISOs and utilities under the **SGDX Working Group** of its non-profit affiliate, **BetterGrids Foundation**, GridBright has proposed a standard NDA form for exchange of CIP data to further facilitate the transfer of data among stakeholders[24].

> Third is **warehousing** the massive amount of data once it has been obtained, standardized and archived with the appropriate protection and the required NDAs.

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[22] Further details available at Open CIP{ Concept Paper by BetterGrids.org available at https://www.gridbright.com/insights/open-cip-concept-whitepaper/

[23] Refer to https://www.nerc.com/pa/Stand/Pages/default.aspx for further details.

[24] Further details may be found at https://www.gridbright.com/gridbright-launches-grideon-secure-grid-collaboration-sgc-as-a-service-to-help-utilities-share-sensitive-data-needed-to-keep-the-lights-on/

Currently no such centralized database exists. What data is available resides among multiple stakeholders and in non-standardized form. GridBright envisions a centralized repository of up-to-date, complete and standardized, transmission-related data with the required NDAs in a centralized, safe repository – the equivalent of the **Fort Knox** for utility transmission data.

This database, once assembled and archived, can be accessible to all who have legitimate need for it.

The final item on the to-do-list is modern **tools and software** to enable users to retrieve the necessary data and perform the required analysis quickly and cheaply.

The ultimate aim is to simplify the user experience to resemble what **Zillow** does for real estate or **Google Maps** does for locating and getting directions to a desired destination. In the case of Google Maps, once the user get to the destination, the same software offers additional services and tips such as where to park, shop or dine.

Similar features can be offered to the users of the transmission data exchange with the main difference being restricted access – only legitimate users will be able to access the data – and strict security and confidentiality – the uses will have to abide by the NDAs and other restriction. ■

HOW AIRIS SYMPLIFIES THE DATA ACCESS PROBLEM

GridBright has proposed to develop and commercialize a user-friendly **Renewable Interconnection Siting** (AIRIS) service to simplify one of the critical aspects of the interconnection problem for renewable energy developers[25].

The vision is to create a *service* that resembles the user experience for **Google Maps** or **Zillow** by incorporating GridBright's interconnection engineering expertise into a user-friendly online service. Once developed, qualified developers and those who are performing POI analysis can quickly find the data they need, in standardized format, along with the security and confidentiality agreements in one place. This capability would significantly accelerate and improve the engineering analysis of the interconnection of renewable resources.

To enhance the user interface and experience, GridBright envisions easy-to-use software enabled by **artificial intelligence** specifically designed to automate the POI selection process from beginning to end while addressing all applicable regulatory compliance and cyber security requirements.

The end product would allow the analysts to ask and get what they need by using a browser and natural language queries. For example, the user can simply type in

> "What is the best place near zip code 12345 to locate a 10 MW solar farm?"

or

> "Where are the best POIs in Zip code 12345?"

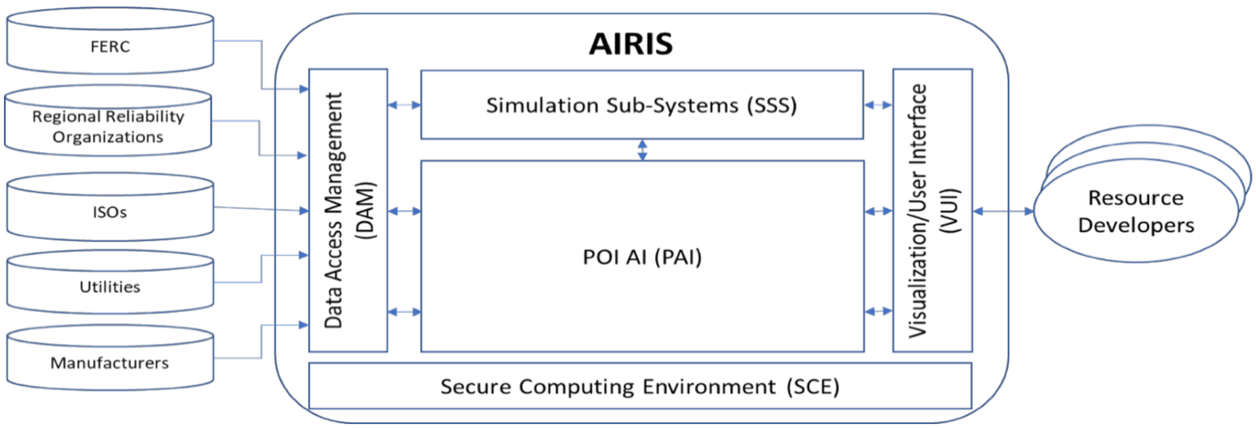
[25] Further details under "Insights" at GridBright's website at https://www.gridbright.com

in the AIRIS software's search box and hit enter. The benefits of having such capability include:

- Significantly faster access to data;
- Significantly faster and cheaper transmission interconnection planning; and
- Significantly reduced cyber security risks.

To deliver the required functionalities AIRIS is envisioned to consists of several components schematically depicted in the exhibit below.

How AIRIS will deliver the desired functionalities



Source: GridBright, Inc.

- **Data Access Management** (DAM) system collects and assembles the data from various sources in standardized form using highly secure transfer protocols with the required disclosure requirements using solutions developed in the ARPA-E **Secure Grid Data Exchange** (SGDX) project[26];
- **Simulation Sub-Systems** (SSS) will be assembled from off-the-shelf commercial powerflow analysis and production simulation software such as **PSLF** and **Plexos**;
- **POI AI sub-system** (PAI) uses existing open-source AI software such as **TensorFlow** or **PyTorch** based on multi-dimensional tensors using injection studies, project queues, price trends, and generator types to pre-calculate millions of scenarios and train models that developers could use by specifying their site requirements and assumptions;
- **Visualization/User Interface** (VUI) is the primary mechanism for developers to examine the results of the analyses through a browser. The goal is to replicate the geospatial navigation and natural language query features found in popular online services. It will leverage the **Grid Model Semantic Searching** technology that GridBright developed for the BetterGrids **Grid Data Repository**[27]; and

[26] Refer to https://www.gridbright.com
[27] Refer to https://www.gridbright.com

- **Secure Computing Environment** (SCE), which will leverage GridBright's **ARPA-E SGDX** solutions running in a domestic high-security GovCloud.

These are complex subsystems requiring innovation and automation to end up with a user-friendly commercial solution that can be offered as **software-as-service** (SaaS) to those who need it.

The benefits of the automation and streamlining that will result, however, should be obvious.

GridBright OFFERS END-TO-END SOLUTION TO DATA ACCESS PROBLEM

While some of the bureaucratic and time-consuming aspects of the process of connecting a new renewable plant or storage project to the transmission network are likely to remain, other aspect of the process can be streamlined, expedited and made more efficient. One area which offers particular potential is streamlining the time-consuming task of getting access to data, which is central to the analysis of the generators' application for interconnection.

GridBright envisions a comprehensive "solution" to address this complex data acquisition and analysis problem.

As described in **Deep Dive 7,** GridBright's proposal is based on years of experience working with stakeholders in the long interconnection supply chain and a deep understanding of the underlying causes of the problem. While others are aware of the issues and/or working on pieces of the solution, no other entity has come up with a comprehensive solution that goes to the core of the issue of quickly getting access to the required data to perform the mandatory engineering analysis.

Deep Dive 7 – Making access to data as easy as locating a destination on Google Maps

GridBright's solution is to develop and maintain a comprehensive and secure database which can be accessed by those who have legitimate need for the information, namely developers and financiers of renewable plants and storage projects.

Creating a national database on the transmission network requires collecting, formatting, archiving, cataloguing, and storing vast amounts of data and placing it in a secure platform accessible to those who need the information to perform the analysis that is needed before new generation – renewable, conventional or storage – can be connected to the grid. The vast amount of data will have to be obtained from multiple sources, with the necessary privacy, confidentiality, and non-disclosure agreements for hosting the data and providing access to the users.

GridBright believes that its grand vision, once implemented, will allow the ultimate users of the data with easy and fast access to reliable, high quality and up-to-date information, which they need to perform the analysis. The envisioned business model for the enterprise is a **software-as-service** (SaaS) scheme with users paying for the privilege to get quick access to the necessary data in real-time.

Various forms of payment may be considered to cover the costs of maintaining and updating the data such as subscription service, pay-as-you-go or a combination of the two. Heavy frequent users may pay an annual subscription fee for access plus a fee per service. Infrequent users may pay a one-time fee for access. ■

WHY GridBright?

The various proposals to accelerate the regulatory approval and permitting process tend to be piecemeal, typically addressing small parts of the problem. While helpful, none address the fundamental problem, which is how to standardize and store the vast amount of confidential and sensitive data required for analysis in a central repository and make it easily available to those who need it. This is precisely what GridBright's proposal offers, namely a comprehensive end-to-end solution.

Moreover, GridBright is uniquely positioned to take on this enormous challenge by leveraging two sets of critical capabilities:

- First, is the automation tools that BridBright's engineers have built to simplify their work based on the collective experience of working with hundreds of clients on interconnection studies over the past few years; and
- Second, the data sharing SaaS solutions that GridBright has already developed with ARPA-E funding over the last 5 years to create the BetterGrids Repository (www.BetterGrids.org) and the Secure Grid Data Exchange solution GRIDEON (www.GRIDEON.com) can be leveraged to develop the AIRIS end-to-end solution to this challenging problem.

Finally, GridBright can implement the proposed solution because it

- Understands the full nature of data access problem;
- Knows what it takes to solve it; and
- Has the resources, capabilities and the necessary experience to assemble and maintain the database.

CREDITS

The following contributed to this White Paper

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