

Hybrid Power Plants

Concepts, barriers to development and proposals

The discussion regarding the possibility of producing energy with more than one primary source, the so-called hybrid power plants, is getting more attention. In Brazil, this issue has gained momentum with the claim that complementarities between certain resources (wind and solar, for example) would allow better use of the existent and planned transmission system.

Project developers and equipment manufacturers have suggested several sources and technology combinations, and they have already tested some of them on small-scale projects. Among the available possibilities, it is possible to mention wind and solar PV; hydro and solar PV; solar thermal and biomass, biomass and natural gas, coal and biomass (co-firing), etc.

However, the integration level varies among these combinations: from power plants that are simply located next to each other, with individual generation, to plants where the primary resources are combined before the transformation to electric energy, which makes it impossible to distinguish the energy that has been generated by each source. Therefore, there is no clear definition of what is a hybrid power plant.

Moreover, present rules are not well suited to this subject, which makes it necessary to identify the obstacles affecting this kind of project and to discuss their limitation and provided benefits.

This report briefly introduces the several identified arrangements and combinations of sources in order to introduce the discussion about their potential benefits and limitations without discussing the tech-

nical details, which are presented on the Technical Report "Usinas Híbridas - Uma análise qualitativa de temas regulatórios e comerciais relevantes ao planejamento" (EPE-DEE-NT-011/2018-r0), available on EPE's website, only in Portuguese.

POSSIBLE SOURCE COMBINATIONS, POTENTIAL BENEFITS AND LIMITATIONS

Among the combinations that are generically called "hybrid power plant", we present four typologies of source integration, which intend to represent the diverse possibilities. For each typology, we seek to identify the benefits, impacts, obstacles to their feasibility and possible actions to eliminate or reduce these barriers.

We illustrate each case by a Figure that shows the combination of wind and solar PV sources, with a corresponding label. We point out that these examples are applicable also to other source combinations.

a) Adjacent power plants

Adjacent power plants are those constructed next to each other, and can even use the same site and share the connection assets. From the connection point of view, each plant must sign up for a grid capacity usage (transmission or distribution) which must be consistent with its installed power according to the current regulation.

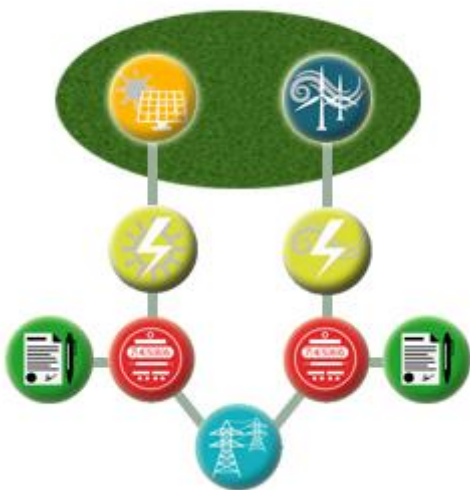
This arrangement allows savings on land use costs and some synergies on logistics, construction and operation. Nevertheless, from the electric system point of view, they are two separated power plants,

since they share no generation equipment. Thus, by this definition, they are not properly hybrid plants.

Some wind farms already use this configuration, associating themselves in complexes, which can also include, for instance, new PV plants.

However, it is important to evaluate a possible interference between the power plants. As an example, a PV plant installed near a wind farm may be subject to losses due to the shading from the tower or the blades. Furthermore, the PV system may interfere on the terrain roughness, affecting the available wind resource for the turbines.

TYPE A - ADJACENT POWER PLANTS



b) Associated power plants

Similar to the adjacent power plants but presenting a higher level of integration: two (or more) power plants that besides being next to each other (possibly on the same site), share the grid use contracts, a physical connection infrastructure and the access to the transmission or distribution grid.

This was the arrangement considered on the studies described in the [Technical Report EPE-DEE-NT-025/2017-r0](#), published by EPE in April 2017 (Portuguese only), which evaluates the wind-PV complementarity on different sites of Northeast Brazil.

Besides the benefits from the former typology, this arrangement would include the acquisition of an amount of grid usage rights that would be lower

than the sum of their individual installed capacities, thus incurring on savings on the grid usage tariffs. This alternative requires, however, a broader discussion, which we address on the Technical Report.

For instance, in certain moments, grid constraints will hamper the produced energy, which will need to be curtailed. This event that may require regulatory and contractual adjustments.

TYPE B - ASSOCIATED POWER PLANTS



c) Hybrid Power Plants

We identify as authentic hybrid power plants the ones in which the sources are combined for the electric energy production, not allowing any kind of distinction of the primary source that has produced the electricity.

A CSP plant with biomass burning, for instance, which produces steam from both sources fits into this category; same for a PV plant that shares the converters with a wind turbine, without the need of PV inverters.

Therefore, the level of integration between sources is even greater in the typology, providing benefits that are similar to the ones in the previous arrangements, with potential for larger savings. In this case, there would be no curtailment, since the constraint takes place on a previous stage, during the electricity production.

TYPE C – HYBRID POWER PLANTS



LABEL:

LOT

SOLAR SOURCE

ELECTRIC ENERGY

WIND SOURCE

CONTRACT (NETWORK USAGE RIGHTS)

METER

NETWORK

OBSTACLES TO HYBRID OR ASSOCIATED PROJECTS AND ACTIONS FOR THEIR SUPPORT

We understand that there are no major constraints for the construction of Adjacent Power Plants (type A) considering the current practices and regulations. However, there are barriers to the development of Associated Power Plants (type B) and Hybrid Power Plants (type C). In the following sessions, we present some of the main challenges focusing on the Brazilian Regulated Market.

d) Commercial Portfolios

The constitution of a commercial portfolio, including projects of different sources is distinct from the previous categories since it does not necessarily require any physical proximity or equipment sharing.

This arrangement does not affect the procurement of grid usage rights, which needs to be individual for each power plant. Its nature is only commercial, as a strategy of asset diversification and risk reduction for the generators, mostly for the case of complementary generation plants regardless of their physical distance.

Among the described typologies, this represents the lowest integration level, thus not benefiting from synergies as the other arrangements.

Hybrid Power Plant definition

The definition of categories for “Hybrid Power Plants” is important for the purpose of regulatory treatment of projects with more than one primary source. This could include both the “Hybrid Power Plant” (type C) as well as the so-called “Associated Power Plant” (type B).

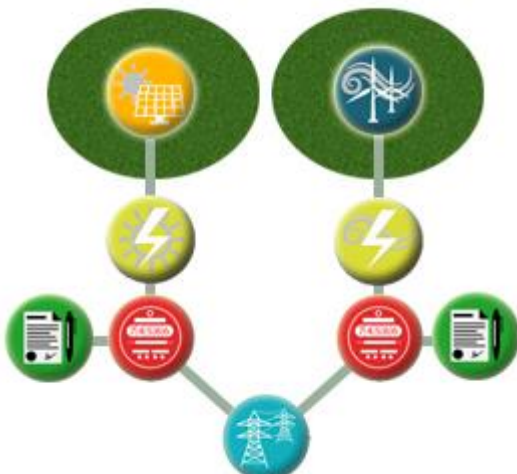
The current Regulatory Agenda (2018-2019) from the Brazilian Electricity Regulatory Agency (ANEEL) includes a Public Consultation on the 2nd semester of 2018 in order to discuss “regulatory adjustments due to the installation of hybrid power plants”. This discussion can provide an adequate treatment for this issue and for the following subjects.

Grid usage rights

According to the present rules, each power plant must procure a grid capacity equal or higher than their installed capacity.

Nevertheless, this rule restricts the main benefit provided by the Associated Power Plants (type B), which would be the acquisition of a grid usage right lower than the sum of the individual installed capac-

TYPE D – COMMERCIAL PORTFOLIOS



ities of both power plants, though it might result in curtailment.

Thus, to allow type B power plants to deliver their maximum generation, it is necessary to modify the current rules and to create regulatory mechanisms that ensure the curtailment of the power surplus, avoiding grid overloads.

This difficulty would not affect Hybrid Power Plants (type C) since they would acquire a grid usage capacity that is at least equal to their installed capacity.

Any changes in this rules and regulations require a broader discussion, in order to preserve an isonomic treatment between agents. It is necessary to discuss, for instance, the possibility of acquiring grid usage rights that would be lower than the installed capacity also for single power plants.

New and existing power plants combination

The installation of combined power plants (of any type) can be done in two different ways:

- Two new power plants, negotiated and built at the same time; or
- One new power plant built next to an existing one that has already been contracted.

Both cases have their issues and limitations. On the second one, for example, when a new power plant combines with one that has been previously contracted, a special care is needed not to violate any contractual rule. In addition, it should be assessed if the original PPA could allow the allocation/accounting of possible curtailment that might occur after the second power plant is deployed.

In any case, it is important to be cautious with price appropriation, which means that a technology with a lower generating cost should not benefit from a higher price due to a previous PPA.

Energy procurement and compensation

The procurement and payment form depends on the considered typology and whether both power plants sign contracts for selling their energy on the same time or in distinct occasions.

In type B combinations (Associated Power Plants), which share the connection point, the power plants could sell their energy and receive their payment individually, whenever individual energy metering is available, or as if they were a single entity. In this case, the source that will be curtailed in the event of a production surplus must be defined beforehand.

Hybrid Power Plants (Type C), in which there is no distinction on the energy source, should have a single revenue, which is not dependent on the individual contribution of each primary source. However, such mechanism hinders the inclusion of these power plants in the energy auctions since each energy source usually participates on specific products with distinct cap prices.

A simpler possibility that promotes greater competition, would be allowing the competition between hybrid-to-be or associate-to-be power plants (types C and B) with similar sources. Due to efficiency gains, these plants should naturally be more competitive.

For this reason, specific auctions or products for such projects seem not to be the preferential way, thus avoiding the difficulties related to the energy pricing, considering the diverse attributes and costs of each source and the several possibilities of technology combinations.

An additional difficulty lies on the physical guarantee¹ calculation for these power plants since the present rules consider particular formulations for each source, and there are no rules for Hybrid Power Plants or for Associated Power Plants, in which

¹ Analogue to firm energy certificates, the physical guarantee is the maximum energy that can be sold by the power plant.

curtailment may happen. Therefore, a proper methodology needs to be established.

Generated energy accounting and clearing

Apart from the distinct means of physical guarantee calculation, depending on the source and on the specific contract, the accounting and clearing of the generated energy have different rules.

In cases where there is availability of individual metering for the energy production of each source, such as Associated Power Plants (type B), it is still possible to have distinct accounting mechanisms for each source. However, considering single measuring on a Hybrid Power Plant (type C), the current accounting rules may not be adequate for certain sources or combinations.

Another difficulty in technology combination would be the PPA types (availability or quantity), which vary for each source or auction. As the energy output accounting is specific for each of these contracts, the revenue and risk allocation of the combined output may not occur adequately.

The adoption of quantity contracts seems to be the most adequate way to ensure the competition on the same base (for portfolios, associated, hybrid or conventional power plants) and enable innovative arrangements that capture efficiency gains, resulting on lower energy prices.

FINAL REMARKS

We presented four typologies of source association, with the A and D types representing low level of physical integration, with no major constraints for their construction. In opposition, the typologies B and C may provide greater benefits to the system but still face regulatory obstacles, which could be mitigated by adopting some measures.

Among the relevant identified points, the following ones were discussed:

(i) The possibility of sharing the grid system capacity rights between power plants, with the permission to procure a grid capacity that is lower than the sum of the individual installed capacities;

(ii) The curtailment treatment, which means the regulation of the non-delivered portion of energy due to the simultaneous production of both power plants;

(iii) An egalitarian treatment for different sources (whenever possible), converging the accounting, the physical guarantee calculations and the PPA terms.

It is important to notice that any discussion brought by this document must be addressed maintaining an isonomic treatment between hybrid power plants and other sources. Moreover, the concession of exclusive benefits for one technology or the creation of rules to satisfy the needs of a specific market segment should be avoided, since it could increase the risk of jeopardizing the competition on energy auctions.

For more details on the points introduced here, we suggest reading the full Technical Report "Usinas Híbridadas - Uma análise qualitativa do ponto de vista regulatório e comercial" (EPE-DEE-NT-011/2018-r0), available at EPE's website (Portuguese only).