H2020 MAGIC PROJECT POLICY BRIEF / OCTOBER 2018

Intermittent renewable energy

What does renewable energy's intermittent nature mean for the energy system, and do we know how to model it?

Overview

The European Union (EU) aims to transform its energy system into a low-carbon, sustainable and resource efficient system. The proposed transformation implies huge changes and would require the reinvention of entire sectors of the economy. The EU's energy policy package, however, focuses on technological changes (*how energy is produced*) rather than functional changes (*what the energy is being used for*). Looking at energy from a functional perspective, intermittent renewable energy needs to be paired with storage to be able to provide the same services as current fossil fueled power plants. In this case study, we look at the implications of storage requirements in a 100% intermittent electricity system in Spain and Germany.

GRID-LEVEL STORAGE

PHS: Pumped Hydroelectric Storage (PHS) accounts for 99% of global grid storage. Water is pumped from a lower reservoir to an upper reservoir, storing excess electricity in the form of potential energy. PHS is strongly limited by geographical context.

BATTERIES: Lithium-ion batteries are a storage option popular in discussions of grid futures. Few large scale projects exist and there is much uncertainty over their lifespan and embodied emissions.

CAES: Compressed Air Energy Storage (CAES), in its current form, stores energy by compressing air in underground caverns. It is not currently deployed on the large scale. Similar to PHS, CAES potential is strongly dependent on geographic context.

How is renewable energy different from other primary energy sources?

From an engineering perspective, different types of power plants may be categorized as baseload, middle-load (aka load following plants) or peak-load depending on which section of the demand curve their electricity covers. Baseload electricity is the section of the demand curve invariant over time, usually provided by nuclear and coal plants. In contrast, peak electricity is provided by plants that can be ramped up rapidly, such as natural gas turbines, generally at the cost of efficiency. This distinction between types of power plant, however, rarely makes it past engineering readings of energy systems. In EU energy modelling, all electricity is considered to be the same and interchangeable, and statistics refer simply to structural aspects.

This distinction between different types of electricity, however, is very important in discussions of renewable energy futures. Renewable energy is outside of human control (we do not decide when the electricity is produced), so it cannot be managed to cover specific sections of the demand curve in the same way that fossil fuel based plants do. This means that comparing renewable electricity generation to fossil electricity generation using yearly statistics is misleading – it is like comparing apples and oranges. In order to discuss renewable electricity as a functional substitute to other types of electricity generation, it needs to be paired with grid flexibility measures, such as storage and curtailment.

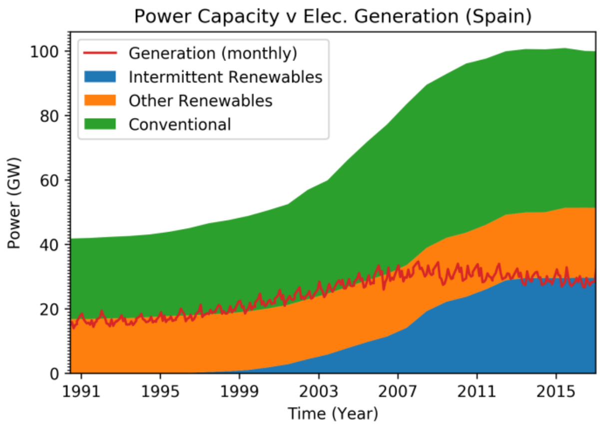
Grid-level storage allows for the output of renewable electricity plants to be under human control by storing excess electricity when it is not needed and releasing it when it is needed. In this way, renewable energy can be used to cover specific sections of the electricity demand curve in a predictable way.

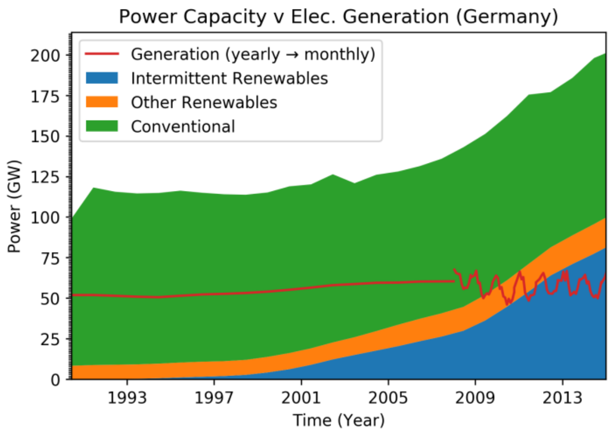
MAGIC NEXUS

Storage requirements in a 100% intermittent electricity system

Adding storage to the discussion of renewable energy futures, it is important to ask how much storage would be needed in an electricity sector dominated by intermittent sources. In this case study, we consider the cases of Germany and Spain. In both of these countries, the installed power capacity of intermittent renewables has been growing rapidly over the past decade. As shown in the figures below, however, this increase has not led to a reduction in conventional power capacity. Using detailed time series data for the two countries, we checked how much storage would be needed in the long-term (2050) in a projected 100% intermittent electricity system by calculating the worst annual hypothetical "failure event" – i.e., the longest time stretch during which each country would need to rely mostly on storage in order to fulfill electricity needs.

The results of our analysis show that **the energy gap would be of the order of 14 TWh in Germany and 6 TWh in Spain**. In practical terms, this means that if each country were to use battery energy storage to cover this gap, **the manufacturing of the batteries alone would result in emissions on the same order of what each country emits on a annual basis**.





Key messages

The EU is aiming to revolutionise its energy system through a radical transition to renewable energy. This transition, however, is being approached from a technological perspective, changing systems of production rather than considering the energy system as an organizational whole. **In MAGIC, we think energy systems should be studied not only in terms of structure, but also in terms of function**. Looking specifically at the electricity sector, **renewable electricity is intermittent: it cannot be compared to other forms of electricity without also associating it with grid flexibility measures, such as storage**. In this case study, we checked how much storage would be needed in Spain and Germany in 2050 for a 100% intermittent electricity system. The results greatly surpass any form of grid-scale storage currently existing. If the energy and power gap were to be covered by lithium-ion batteries, they would lead to high GHG emissions due to battery manufacturing, offsetting the positive environmental effects of renewable energy. To find out more about case study, see Renner and Giampietro (2018) [1].

References

[1] *Renner, A.; Giampietro, M. The Regulation of Alternatives in the Electric Grid: Nice Try Guys, But Let's Move On. In International Conference on Sustainable Energy and Environment Sensing (SEES); University of Cambridge, Cambridge, UK, 2018*

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