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# Impact of climate change on high-VRE optimal mixes and system costs: the case of France.

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High-Variable Renewable Energies (VREs) power systems are becoming a cornerstone of climate change mitigation policies across Europe. At the same time, committed and potential climate change will impact energy systems as a whole, both from the supply and demand side. Current power systems are expected to change drastically in the future, in particular in terms of VRE penetration. Finding the best mix for a given country is a complex problem that depends on multiple social, economical and political criteria. Instead of prescribing future capacities, economically optimal VRE mixes that ensure system adequacy can be used. We focus in this study on the impact of climate change on these optimal VRE mixes, as well as on the associated system costs. The study is narrowed to the case of France, which is a highly temperature sensitive country with high VRE potential resources. An ensemble of six model pairs from the EURO-CORDEX (CMIP5) project is used to obtain the meteorological variables of interest under different levels of climate change. The open source software e4clim is used to determine the economically optimal mixes. Socioeconomic scenarios of electrification are derived to study the effect of an increased base load and temperature sensitivity. We find that for the case of France increasing climate change tends to decrease demand. The PV resource is not affected significantly whereas the wind resource decreases over the whole country and up to 10 % in some regions. We show that these impacts lead to changing optimal VRE mixes. Although the installed photovoltaic (PV) capacity is not affected by climate change, except for its geographic distribution under some socioeconomic scenarios, so does the installed wind capacity. No matter the socioeconomic scenario, installed wind capacity is found to be the adjustment variable when demand decreases due to climate change: even though the wind capacity factor decreases, less capacity needs to be installed. In parallel, increasing levels of climate change lead to decreased system total costs: less VRE generation capacity is installed and generation costs for the dispatchable producers are decreased. These cost differences are up to 10 % and amount up to 6 G€ depending on the socioeconomic scenario considered. We finally find that the system marginal cost is not significantly affected by climate change. Underestimating future climate change in planification could thus lead to stranded wind farm assets up to 10 % of the installed fleet, corresponding to up to a 2 G€ loss. If stranded assets are avoided by anticipating the right climate change scenario, then adverse impacts of climate change are found to be minimal, since the cost for dispatchable producers tends to decrease and the system marginal cost is not affected. If only economically optimal VRE mixes were considered here, those can then be put under suboptimal climatic and

socioeconomic conditions, paving the way to take into account the uncertainty related to climate change and socioeconomic development when dealing with VRE mix planification issues.