RESPONSE TO JACOBSON ET AL. CLAIM THAT THERE ARE MANY 100% RE STUDIES THAT BACK UP THEIR CLAIM TO RELY ALMOST ENTIRELY ON WIND, SOLAR, AND HYDRO

Mason et al. (2010): A 100% renewable electricity generation system for New Zealand utilising hydro, wind, geothermal and biomass resources

The New Zealand electricity generation system is dominated by hydro generation at approximately 60% of installed capacity between 2005 and 2007, augmented with approximately 32% fossil-fuelled generation, plus minor contributions from geothermal, wind and biomass resources. In order to explore the potential for a 100% renewable electricity generation system with substantially increased levels of wind penetration, fossil-fuelled electricity production was removed from an historic 3-year data set, and replaced by modelled electricity production from **wind, geothermal and additional peaking options**. Generation mixes comprising **53–60% hydro, 22–25% wind, 12–14% geothermal, 1% biomass and 0–12% additional peaking generation** were found to be feasible on an energy and power basis, whilst maintaining net hydro storage. Wind capacity credits ranged from 47% to 105% depending upon the incorporation of demand management, and the manner of operation of the hydro system. Wind spillage was minimized, however, a degree of residual spillage was considered to be an inevitable part of incorporating non-dispatchable generation into a stand-alone grid system. Load shifting was shown to have considerable advantages over installation of new peaking plant. Application of the approach applied in this research to countries with different energy resource mixes is discussed, and options for further research are outlined.

Comment [CC1]: Mostly hydro based in NZ. Still includes 12-14% geothermal. Wind less than 25% - agrees with our arguments!

Hart and Jacobson (2011): A Monte Carlo approach to generator portfolio planning and carbon emissions assessments of systems with large penetrations of variable renewables

A new generator portfolio planning model is described that is capable of quantifying the carbon emissions associated with systems that include very high penetrations of variable renewables. The model combines a deterministic renewable portfolio planning module with a Monte Carlo simulation of system operation that determines the expected least-cost dispatch from each technology, the necessary reserve capacity, and the expected carbon emissions at each hour. Each system is designed to meet a maximum loss of load expectation requirement of 1 day in 10 years. The present study includes wind, centralized solar thermal, and rooftop photovoltaics, as well as hydroelectric, geothermal, and natural gas plants. The portfolios produced by the model take advantage of the aggregation of variable generators at multiple geographically disperse sites and the incorporation of meteorological and load forecasts. Results are presented from a model run of the continuous two-year period, 2005-2006 in the California ISO operating area. **A low-carbon portfolio is produced for this system that is capable of achieving an 80% reduction in electric power sector carbon emissions from 2005 levels and supplying over 99% of the annual delivered load with non-carbon sources**. A portfolio is also built for a projected 2050 system, which is capable of providing **96% of the delivered electricity from non-carbon sources**, despite a projected doubling of the 2005 system peak load. The results suggest that further reductions in carbon emissions may be achieved with emerging technologies that can reliably provide large capacities without necessarily providing positive net annual energy generation. These technologies may include demand response, vehicle-to-grid systems, and large-scale energy storage.

Comment [CC2]: Yep, 80% reduction. Not 100%. Not 100% variable generation either.

See their figure 3 of https://web.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/HartJacRenEnMar11.pdf and see that they have 10s of GW of NG reserves! From their table 3, it shows 72 GW of NG back up (in other words 26% of capacity).

How is it possible to have a fleet of 72 GW of natural gas at a CF of 2.6% as they claim??

Hart and Jacobson (2012): The carbon abatement potential of high penetration intermittent renewables

The carbon abatement potentials of wind turbines, photovoltaics, and concentrating solar power plants were investigated using dispatch simulations over California with 2005–06 meteorological and load data. A parameterization of the simulation results is presented that provides approximations of both low penetration carbon abatement rates and maximum carbon abatement potentials based on the temporal characteristics of the resource and the load. The results suggest that shallow carbon emissions reductions (up to 20% of the base case) can be achieved most efficiently with geothermal power and demand reductions via energy efficiency or conservation. Deep emissions reductions (up to 89% for this closed system), however, may require the build-out of very large fleets of intermittent renewables and improved power system flexibility, communications, and controls. At very high penetrations, combining wind and solar power improved renewable portfolio performance over individual build-out scenarios by reducing curtailment, suggesting that further reductions may be met by importing uncorrelated out-of-state renewable power. **The results also suggest that 90–100% carbon emission reductions will rely on the development of demand response and energy storage facilities with power capacities of at least 65% of peak demand and energy capacities large enough to accommodate seasonal energy storage**.

Comment [CC3]: Exactly as we state to do high penetrations of intermittent renewables, they need huge storage reservoirs!

See their paper here:
https://web.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/HartEES12Online.pdf

Connolly et al. (2011): The first step towards a 100% renewable energy-system for Ireland

In 2007 Ireland supplied 96% of the total energy demand with fossil fuels (7% domestic and 89% imported) and 3% with renewable energy, even though there are enough renewable resources to supply all the energy required. As energy prices increase and the effects of global warming worsen, it is essential that Ireland begins to utilise its renewable resources more effectively. Therefore, this study presents the first step towards a 100% renewable energy-system for Ireland. The energy-system analysis tool used was EnergyPLAN, as it accounts for all sectors of the energy-system that need to be considered when integrating large penetrations of renewable energy: the electricity, heat, and transport sectors. Initially, a reference model of the existing Irish energy-system was constructed, and subsequently three different 100% renewable energy-systems were created with each focusing **on a different resource: biomass, hydrogen, and electricity**. These energy-systems were compared so that **the benefits from each could be used to create an 'optimum' scenario** called combination. Although the results illustrate a potential 100% renewable energy-system for Ireland, they have been obtained based on numerous assumptions. Therefore, these will need to be improved in the future before a serious roadmap can be defined for Ireland's renewable energy transition.

Connolly and Mathiesen (2014): A technical and economic analysis of one potential pathway to a 100% renewable energy system

This paper outlines how an existing energy system can be transformed into a 100% renewable energy system. The transition is divided into a number of key stages which reflect key **radical technological changes** on the supply side of the energy system. Ireland is used as a case study, but in reality, this reflects many typical energy systems today which use power plants for electricity, individual boilers for heat, and oil for transport. The seven stages analysed are 1) reference, **2) introduction of district heating, 3) installation of small and large-scale heat pumps, 4) reducing grid regulation requirements, 5) adding flexible electricity demands and electric vehicles, 6) producing synthetic methanol/DME for transport, and finally 7) using synthetic gas to replace the remaining fossil fuels**. For each stage, the technical and economic performance of the energy system is calculated. The results indicate that a 100% renewable energy system can provide the same end-user energy demands as today's energy system and at the same price. Electricity will be the backbone of the energy system, but the flexibility in today's electricity sector will be transferred from the **supply side of the demand side in the future**. Similarly, due to changes in the type of spending required in a 100% renewable energy system, this scenario will result in the creation of 100,000

Comment [CC4]: Full text here: https://www.researchgate.net/publication/222545427_The_first_step_towards_a_100_renewable_energy-system_for_Ireland

Comment [CC5]: See their figure 5 and it is clear their optimum solution is mostly dispatchable biomass, not variable generation!

Comment [CC6]: Full text here: http://vbn.aau.dk/files/197397631/DC_BVM.pdf

Comment [CC7]: They introduce many flexible pathways into this 100% modeled future that include synthetic fuels and huge flexibility in the demand side.

Comment [CC8]: Completely changing the grid to be flexible to meet the supply. We state this point in the PNAS paper, in which if you change demand to match supply it is easy.

additional jobs in Ireland compared to an energy system like today's. These results are significant since they indicate that the transition to a 100% renewable energy system can begin today, without increasing the cost of energy in the short- or long-term, if the costs currently forecasted for 2050 become a reality.

Connolly et al. (2016): Smart Energy Europe: The technical and economic impact of one potential 100% renewable energy scenario for the European Union

This study presents one scenario for a 100% renewable energy system in Europe by the year 2050. The transition from a business-as-usual situation in 2050, to a 100% renewable energy Europe is analysed in a series of steps. Each step reflects one major technological change. For each step, the impact is presented in terms of energy (primary energy supply), environment (carbon dioxide emissions), and economy (total annual socio-economic cost). The steps are ordered in terms of their scientific and political certainty as follows: **decommissioning nuclear power, implementing a large amount of heat savings, converting the private car fleet to electricity, providing heat in rural areas with heat pumps, providing heat in urban areas with district heating, converting fuel in heavy-duty vehicles to a renewable electrofuel, and replacing natural gas with methane**. The results indicate that by using the Smart Energy System approach, a 100% renewable energy system in Europe is technically possible without consuming an unsustainable amount of bioenergy. This is due to the additional flexibility that is created by connecting the electricity, heating, cooling, and transport sectors together, which enables an intermittent renewable penetration of over 80% in the electricity sector. The cost of the Smart Energy Europe scenario is approximately **10–15% higher than a business-as-usual scenario**, but since the final scenario is based on local investments instead of imported fuels, it will create approximately 10 million additional direct jobs within the EU.

Comment [CC9]: Full text here: https://pire.soe.ucsc.edu/sites/default/files/Smart%20energy%20Europe_Connolly.pdf

They do not consider transmission in this and ignore certain technologies from the beginning.

Comment [CC10]: Huge changes in the behavior of the grid to support variable generation. Large amounts of synthetic fuels.

Comment [CC11]: More expensive than BAU…

Mathiesen et al. (2011): 100% Renewable energy systems, climate mitigation and economic growth

Greenhouse gas mitigation strategies are generally considered costly with world leaders often engaging in debate concerning the costs of mitigation and the distribution of these costs between different countries. In this paper, the analyses and results of the design of a 100% renewable energy system by the year 2050 are presented for a complete energy system including transport. Two short-term transition target years in the process towards this goal are analysed for 2015 and 2030. The energy systems are analysed and designed with hour-by-hour energy system analyses. The analyses reveal that implementing energy savings, renewable energy and more efficient conversion technologies can have positive socio-economic effects, create employment and potentially lead to large earnings on exports. If externalities such as health effects are included, even more benefits can be expected. **100% Renewable energy systems will be technically possible in the future, and may even be economically beneficial compared to the business-as-usual energy system**. Hence, the current debate between leaders should reflect a combination of these two main challenges.

Comment [CC12]: Only economic if bring in healthcare costs. Also, they again use synthetic fuels etc. driving flexibility on the demand side. Something that is hard to achieve cheaply.

Mathiesen et al. (2011): Smart Energy Systems for coherent 100% renewable energy and transport solutions

Comment [CC13]: Full text here: https://www.researchgate.net/publication/273401196_Smart_Energy_Systems_for_coherent_100_renewable_energy_and_transport_solutions

The hypothesis of this paper is that in order to identify least cost solutions of the integration of fluctuating renewable energy sources into current or future 100% renewable energy supplies one has to take a Smart Energy Systems approach. This paper outline why and how to do so. Traditionally, significant focus is put on the electricity sector alone to solve the renewable energy integration puzzle. Smart grid research traditionally focuses on ICT, smart meters, electricity storage technologies, and local (electric) smart grids. In contrast, the Smart Energy System focuses on merging the electricity, heating and transport sectors, in combination with **various intra-hour, hourly, daily, seasonal and biannual storage options, to create the flexibility necessary to integrate large penetrations of fluctuating renewable energy**. However, in this paper we present the development and design of coherent Smart Energy Systems as an integrated part of achieving future **100% renewable energy** and transport solutions. The transition from fossil fuels towards the integration of more and more renewable energy requires rethinking and redesigning the energy system both on the generation and consumption side. To enable this, the Smart Energy System must have a number of appropriate infrastructures for the different sectors of the energy system, which are smart electricity grids, smart thermal grids (district heating and cooling), smart gas grids and other fuel infrastructures. It enables fluctuating renewable energy (such as wind, solar, wave power and low value heat sources) to utilise new sources of flexibility such as solid, gaseous, and liquid fuel storage, thermal storage and heat pumps and battery electric vehicles. Smart Energy Systems also enable **a more sustainable and feasible use of bioenergy than the current types allow**. It can potentially pave the way to a bioenergy-free 100% renewable energy and transport system.

Comment [CC14]: Again, back to the seasonal storage needs and demand side flexibility to solve the variability problem.

Comment [CC15]: See their Figure 8, and it can be seen that only 44.3% of their energy comes from WWS and the rest is biomass, bioenergy and geothermal!

Comment [CC16]: Bioenergy is used also…

Denholm and Hand (2011): Grid flexibility and storage required to achieve very high penetration of variable renewable electricity

We examine the changes to the electric power system required to incorporate high penetration of variable wind and solar electricity generation in a transmission constrained grid. Simulations were performed in **the Texas, US (ERCOT) grid** where different mixes of wind, solar photovoltaic and concentrating solar power **meet up to 80% of the electric demand**. The primary constraints on incorporation of these sources at large scale are the limited time coincidence of the resource with normal electricity demand, combined with the limited flexibility of thermal generators to reduce output. An additional constraint in the ERCOT system is the current inability to exchange power with neighboring grids.

By themselves, these constraints would result in unusable renewable generation and increased costs. But a highly flexible system – with must-run baseload generators virtually eliminated – **allows for penetrations of up to about 50% variable generation with curtailment rates of less than 10%.** For penetration levels up to 80% of the system's electricity demand, keeping curtailments to less than 10% requires a combination of l**oad shifting and storage equal to about one day of average demand**.

Elliston et al. (2012): Simulations of scenarios with 100% renewable electricity in the Australian National Electricity Market

As a part of a program to explore technological options for the transition to a renewable energy future, we present simulations for 100% renewable energy systems to meet actual hourly electricity demand in the five states and one territory spanned by the **Australian National Electricity Market (NEM)** in 2010. The system is based on commercially available technologies: concentrating solar thermal (CST) power with thermal storage, wind, photovoltaic (PV), **existing hydro and biofuelled gas turbines**. Hourly solar and wind generation data are derived from satellite observations, weather stations, and actual wind farm outputs. **Together CST and PV contribute about half of total annual electrical** energy supply. A range of 100% renewable energy systems for the NEM are found to be technically feasible and meet the NEM reliability standard. The principal challenge is meeting peak demand on winter evenings following overcast days when CST storage is partially charged and sometimes wind speeds are low. **The model handles these circumstances by combinations of an increased number of gas turbines and reductions in winter peak demand**. There is no need for conventional base-load power plants. The important parameter is the reliability of the whole supply-demand system, not the reliability of particular types of power plants.

Elliston et al. (2013): Least cost 100% renewable electricity scenarios in the Australian National Electricity Market

Comment [CC17]: Only performed on ERCOT…

Comment [CC18]: Only up to 80% as we discuss. We do not deny large amounts of wind and solar, but nearly 100% is difficult and not advised for costs.

Comment [CC19]: Agreed, as we discuss.

Comment [CC20]: Back to huge amounts of demand flexibility to get up to 80%!

Comment [CC21]: Full text here: http://www.energy-without-carbon.org/sites/default/files/UNSW-100pcCleanEnergy.pdf

Comment [CC22]: Only considers a small (in terms of energy) grid over large geography

Comment [CC23]: Gas turbines, using synthetic fuels… Their section 4.6 shows that they need 28% of capacity in gas turbines for back-up. As we describe – need back up thermal generation.

Comment [CC24]: 50% not 100% from these…

Comment [CC25]: Change the demand and have backup-thermal generation. Our main point in the paper to deal with the variability.

Comment [CC26]: Full text here: http://www.ies.unsw.edu.au/sites/all/files/profile_file_attachments/LeastCostElectricityScenariosInPress2013.pdf

Least cost options are presented for supplying the Australian National Electricity Market (NEM) with 100% renewable electricity using wind, photovoltaics, concentrating solar thermal (CST) with storage, **hydroelectricity and biofuelled gas turbines**. We use a genetic algorithm and an existing simulation tool to identify the lowest cost (investment and operating) scenarios of renewable technologies and locations for **NEM regional hourly demand** and observed weather in 2010 using projected technology costs for 2030. These scenarios maintain the NEM reliability standard, limit hydroelectricity generation to available rainfall, and limit bioenergy consumption. The lowest cost scenarios are dominated by wind power, with smaller contributions from photovoltaics **and dispatchable generation: CST, hydro and gas turbines**. The annual cost of a simplified transmission network to balance supply and demand across NEM regions is a small proportion of the annual cost of the generating system. Annual costs are compared with a scenario where fossil fuelled power stations in the NEM today are replaced with modern fossil substitutes at projected 2030 costs, and a carbon price is paid on all emissions. **At moderate carbon prices, which appear required to address climate change, 100% renewable electricity would be cheaper on an annual basis than the replacement scenario**.

Comment [CC27]: Back up generation required yet again.

Comment [CC28]: Small grid again…

Comment [CC29]: Small amount? But need 65% of the peak load as capacity. That is 22-23 GW of capacity.

Comment [CC30]: With carbon tax it would be cheaper, not without.

Elliston et al. (2015): Not known to me

Rasmussen et al. (2012): Storage and balancing synergies in a fully or highly renewable pan-European power system

Through a parametric time-series analysis of eight years of hourly data, we quantify the storage size and balancing energy needs for highly and fully renewable European power systems for different levels and mixes of wind and solar energy. By applying a dispatch strategy that minimizes the balancing energy needs for a given storage size, the interplay between storage and balancing is quantified, providing a hard-upper limit on their synergy. An efficient but relatively small storage reduces balancing energy needs significantly due to its **influence on intra-day mismatches**. Furthermore, we show that combined with a low-efficiency hydrogen storage and a level of balancing equal to what is today provided by storage lakes, it is sufficient to meet the European electricity demand in a fully renewable power system where the average power generation from combined wind and solar exceeds the demand by only a few percent.

Comment [CC31]: Full text here: http://mediatum.ub.tum.de/doc/1120528/document.pdf

Comment [CC32]: Intra-day only.

Comment [CC33]: In their conclusions, they state the storage needed may not be feasible to site. They do not consider transmission congestion or issues.

Nelson et al. (2012): High-resolution modeling of the western North American power system demonstrates low-cost and low-carbon futures

Comment [CC34]: Full text here: https://rael.berkeley.edu/wp-content/uploads/2015/04/Nelson-Kammen-SWITCH-EnergyPolicy-2012.pdf

Decarbonizing electricity production is central to reducing greenhouse gas emissions. Exploiting intermittent renewable energy resources demands power system planning models with high temporal and spatial resolution. We use a mixed-integer linear programming model – SWITCH – to analyze least-cost generation, storage, and transmission capacity expansion for western North America under various policy and cost scenarios. Current renewable portfolio standards are shown to be insufficient to meet emission reduction targets by 2030 without new policy. With stronger carbon policy, consistent with a 450-ppm climate stabilization scenario, power sector emissions can be reduced to 54% of 1990 levels by 2030 using different portfolios of existing generation technologies. Under a range of resource cost scenarios, most coal power plants would be **replaced by solar, wind, gas, and/or nuclear generation, with intermittent renewable sources providing at least 17% and as much as 29% of total power by 2030**. The carbon price to induce these deep carbon emission reductions is high, but, assuming carbon price revenues are reinvested in the power sector, the cost of power is found to increase **by at most 20% relative to business-as-usual projections**.

Comment [CC35]: Again, agrees with our assessment that VRE can be around 30-80% not more.

Comment [CC36]: They claim even this is more expensive, because they do not consider long-distance HVDC as an option.

Budischak et al. (2013): Cost-minimized combinations of wind power, solar power and electrochemical storage, powering the grid up to 99.9% of the time

Comment [CC37]: Full text here: http://www.sciencedirect.com/science/article/pii/S0378775312014759

We model many combinations of renewable electricity sources (inland wind, offshore wind, and photovoltaics) with electrochemical storage (batteries and fuel cells), incorporated into **a large grid system (72 GW).** The purpose is twofold: 1) although a single renewable generator at one site produces intermittent power, we seek combinations of diverse renewables at diverse sites, with storage, that are not intermittent and satisfy need a given fraction of hours. And 2) we seek minimal cost, calculating true cost of electricity without subsidies and with inclusion of external costs. Our model evaluated over 28 billion combinations of renewables and storage, each tested over 35,040 h (four years) of load and weather data. We find that the **least cost solutions yield seemingly-excessive generation capacity—at times, almost three times the electricity needed to meet electrical load**. This is because diverse renewable generation and the excess capacity together meet electric load with less storage, lowering total system cost. At 2030 technology costs and with excess electricity displacing natural gas, we find that the electric system can be powered **90%–99.9%** of hours entirely on renewable electricity, at costs comparable to today's—but only if we optimize the mix of generation and storage technologies.

Comment [CC38]: Not a large system, the US is 1,100 GW; this is 72 GW or 7% of the US.

Comment [CC39]: They agree that high 99%+ of VRE results in excessive over capacity.

Comment [CC40]: They still have back up generation for the grid. 28 GW of the 238 GW needed for a 72 GW peak demand. Also 52 GW of storage. Therefore, storage discharging with fossil can meet the PEAK load.

Steinke et al. (2013): Grid vs. storage in a 100% renewable Europe

Intermittent renewable power production from wind and sun requires significant backup generation to cover the power demand at all times. This holds even if wind and sun produce on average 100% of the required energy. Backup generation can be reduced through storage – averaging in time – and/or grid extensions – averaging in space. This report examines the interplay of these technologies with respect to the reduction of required backup energy. We systematically explore a wide parameter space of combinations of both technologies. Our simple, yet informative approach quantifies the backup energy demand for each scenario. We also estimate the resulting total system costs which allow us to discuss **cost-optimal system designs.**

Comment [CC41]: They are stating what we agree with. Need large space and time averaging. Go big, in time and/or space.

Comment [CC42]: It doesn't state whether these systems are cheaper than alternatives.

Becker et al. (2014): Features of a fully renewable US electricity system: Optimized mixes of wind and solar PV and transmission grid extensions

A future energy system is likely to rely heavily on wind and solar PV. To quantify general features of such a weather dependent electricity supply in the contiguous US, wind and solar PV generation data are calculated, based on 32 years of weather data with temporal resolution of 1 h and spatial resolution of **40x40 km2**, assuming site-suitability-based and stochastic wind and solar capacity distributions. The regional wind-and-solar mixes matching load and generation closest on seasonal timescales cluster around 80% solar share, owing to the US summer load peak. This mix more than halves long-term storage requirements, compared to wind only. The mixes matching generation and load best on daily timescales lie at about 80% wind share, due to the nightly gap in solar production. Going from solar only to this mix reduces backup energy needs by about 50%. Furthermore, we calculate shifts in FERC (Federal Energy Regulatory Commission)-level LCOE (Levelized Costs Of Electricity) for wind and solar PV due to differing weather conditions. **Regional LCOE vary by up to 29%, and LCOE-optimal mixes largely follow resource quality**. A transmission network enhancement among FERC regions is constructed to transfer high penetrations of solar and wind across FERC boundaries, employing a novel least-cost optimization.

Comment [CC43]: Full text here: http://web.stanford.edu/group/efmh/jacobson/Articles/Others/BeckerEnergy14.pdf

Comment [CC44]: All aggregated to one spatial point for each FERC region

Comment [CC45]: Everything is randomly placed…

Comment [CC46]: Don't state whether the system is lower-cost than today…

Bogdanov and Breyer (2016): North-East Asian Super Grid for 100% renewable energy supply: Optimal mix of energy technologies for electricity, gas and heat supply options

In order to define a cost optimal 100% renewable energy system, an hourly resolved model has been created based on linear optimization of energy system parameters under given constrains. The model is comprised of five scenarios for 100% renewable energy power systems in North-East Asia with different high voltage direct current transmission grid development levels, including industrial gas demand and additional energy security. Renewables can supply enough energy to cover the estimated electricity and gas demands of the area in the year 2030 and deliver more than 2000 TW h_{th} of heat on a cost competitive level of 84 €/MW h_{el} for electricity. Further, this can be accomplished for a synthetic natural gas price at the 2013 Japanese liquefied natural gas import price level and at no additional generation costs for the available heat. The total area system cost could reach 69.4 €/MW h_{el}, if only the electricity sector is taken into account. In this system about 20% of the energy is exchanged between the 13 regions, reflecting a rather decentralized character which is supplied 27% by stored energy. **The major storage technologies are batteries for daily storage and power-to-gas for seasonal storage.** Prosumers are likely to play a significant role due to favourable economics. A highly resilient energy system with very high energy security standards would increase the electricity cost by 23% to 85.6 €/MW h_{el}. The results clearly show that a 100% renewable energy based system is **feasible and lower in cost than nuclear energy and fossil carbon capture and storage alternatives**.

Comment [CC47]: Yes, with reduced form transmission of only a few connections modeled between this large area 100% is shown to cost 84 euros. Not all is modeled that is needed and resolution of model is low, and they use P2G2P!

Comment [CC48]: Seasonal storage needed again.

Comment [CC49]: It doesn't show this because they do not include them in the model from the outset. It shows it is low-cost, with the many assumptions [only 13 links for all of east Asia] and cheap input costs for VRE and storage conversion technologies.