Justice, poverty, and electricity decarbonization

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Abstract:

Drawing from examples in Germany, California, and Australia, we show that large scale integration of renewable energy in existing electricity grids does not necessarily lead to cheaper electricity, the strengthening of energy security, or the enhancement of economic equity. Indeed, efforts to integrate renewable energy into the grid can thwart efforts to reduce chronic poverty. Planners around the world need to be cautious, pragmatic and realistic when attempting to similarly decarbonize their energy systems.

Main Text:

It may seem perplexing, but despite increasing electricity supply capacity in many industrialized nations, and notwithstanding rapidly declining renewable energy costs (especially for wind turbines and solar photovoltaic panels), electricity prices and bills are increasing in most countries of the world. As a case in point, the energy transition in Germany (the much studied *Energiewende*) has seen non-hydro renewable energy increase from 15% to 35% of its fuel mix between 2010 and 2017 (1). Over the same period, Germany's residential electricity tariffs have increased by 16% (Fig. 1a), considerably more than in most other European countries.

Similarly, California's non-hydro renewable generation grew from 11% to 26% of total generation between 2010 and 2017. Over the same period, average residential electricity prices increased by 10% (Fig. 1b), and state residents are paying considerably more than the national average for their electricity (2). With surplus electricity exceeding 15% and further predicted surpluses of 6% in the next three years (3), the economic principles of demand and supply *should* mean that electricity rates would fall.

Australia's renewable energy development is also challenged by rising electricity rates. Its non-hydro renewable energy grew from 4% to 9% of generation between 2010 and 2017, and over the same period, the average residential electricity price in Australia increased by 12% (Fig. 1c). With rising tariffs, there are more energy-poor households (5, 6). A *decarbonization paradox* could be emerging – a situation where apparently beneficial increases in electricity supply capacity coupled with a more diversified and renewable energy mix is being achieved at the expense of household energy security and affordability.

This paradox becomes all the more important when considering that many countries with significant poverty also seek to adopt renewables, including those most committed to the Paris Accord and those committed to doubling renewable energy capacity under Sustainable Development Goal 7 (SDG7). What is more, the scale of this potential *decarbonization paradox* is not trivial: as of the end of 2017, sector-specific targets for renewable power were in place in 146 countries, with additional targets for renewable heating and cooling and renewable transport in 48 and 42 countries, respectively (7).

Unintended consequences

To be sure, the decarbonization of the German, Californian, and Australian electricity grids has brought significant benefits. Of particular note, renewable energy technologies (RETs) are labour intensive and are thus capable of boosting employment.

For instance, Germany posted a gain of 322,000 jobs in the renewables sector in 2016, especially from the wind, geothermal and bioenergy sectors (7). Similarly, in the U.S. energy workforce in 2017, solar energy firms employed 350,000 individuals, and an additional 107,000 workers were employed in wind energy firms (8). Benefits in California extend to addressing issues of minority representation in the workforce and improving enrolments into the apprenticeship programs of the 16 union locals of electricians, ironworkers, and operators that have built most of the renewable energy power plants in California (9). Likewise, Australia experienced a 33% increase in full-time employment (FTE) in renewable energy between 2015/16 and 2016/17 (10).

Besides job creation, co-benefits of solar and wind encompass cleaner air and water, improved health, the development of new industries, decreasing energy imports, and diversification, amongst others. As indicative examples, the renewable energy roll-out is correcting the negative environmental externalities of fossil fuel combustion. About €8.8 billion of primary fuel import costs in Germany were avoided in 2015 due to renewable energies (11). Further, the continued roll-out of RETs and energy-efficiency programs resulted in significant 6% reductions in energy intensity for both Germany and Australia between 2013 and2015 (12).

However, such gains have come at the cost of four largely unintended effects: growing energy dependence, increasing renewable energy curtailment and capacity firming (defined as using conventional generation sources like coal, natural gas and nuclear to mitigate against the variability of wind and solar), limited greenhouse gas (GHG) reductions, and increased vulnerability among some "losers."

Growing energy dependence

While decarbonization has enhanced some elements of national energy security, it has eroded other dimensions. The *Energiewende* has seen Germany become increasingly dependent on its neighbors (the Czech Republic, Poland, the Netherlands, Belgium and France) to balance and import occasional excess power generation. In 2016, it was reported that despite being a net electricity exporter, Germany imported about 37 TWh from France (13).

The California grid region imports a net daily average of 201 GWh (about 26% of its average daily demand) throughout the year from other western regions (14). This has motivated California's Governor to propose the creation of a larger regional power planning system. This will help to address the problem that "at certain times of the year, California produces more solar and wind energy than it can use, and must pay other states to take it to avoid overloading the system and causing blackouts" (15).

Similarly in Australia, despite wind and PV contributing over 48% of electricity generation for the Southern Australia region, electricity imports increased for the southern region by 40% between 2015/16 and 2016/17 (16).

Increasing curtailment and capacity firming

Aggressive electricity decarbonization is being matched with growing renewable energy curtailment or more capacity firming using conventional generation sources. Using the German case again, the curtailment rate for wind farms (defined as an involuntary reduction in the output of a generator) rose 27-fold between 2000 and 2016 with congestion management costs expected to remain high in coming years (17).

Similarly, in California, the 'Duck Curve' that highlights the non-correlation between PV power production and demand over the course of the day has seen increasing curtailment, particularly when solar penetration exceeds 30% of the fuel mix. Between 2015 and 2016, curtailment rates for wind and solar rose from 187 GWh to 308 GWh per annum (18).

In Australia, the growing integration of VRE has not led to a decline in reliance on traditional generation sources (19). For instance, in South Australia, increasing wind penetration is being matched with increasing capacity firming necessitating the Australian Energy Market Operator (AEMO) to mandate that a minimum level of synchronous generation capacity be maintained online at all times for managing system strength. Furthermore, the mandated minimum level is subject to further increase as non-synchronous electricity generation capacity (mostly from wind turbines) increases (20).

Meager climate change abatement

In some situations, the rise of renewables has not led to a corresponding reduction in greenhouse gas emissions. While renewables in Germany's electricity grid has increased, so have CO_2 emissions from its power sector due to the increased burning of lignite to stabilise production (21). As a result, Germany is set to miss its 2020 emissions target.

In California, despite a 24%, 14% and 13% decline in GHG emissions from the electricity consumed by the commercial, residential, and industrial sectors respectively between 1990 and 2015, 2015 GHG emissions levels were still 2% higher than 1990 levels due, in part, to increased GHG emissions from transport and agriculture (22). In fact, California's ambitious renewable energy program notwithstanding, the state ranked second in CO_2 emissions (only behind Texas) in the U.S. in 2015 2015 (23).

In Australia, there has been a consistent increase in GHG emissions for three years running due to 3.4%, 3.8% and 3.9% annual increases in non-renewable electricity generation in recent years (24).

Worsening vulnerability and poverty

Increases in renewable electricity can enhance some aspects of vulnerability, creating so called political economy "losers." In contrast to the employability positives given above, one source is the job losses associated with the displacement of coal, natural gas and oil (due, in part, to the non-transferability of skills) (25). While job losses might in theory be offset by job gains in the renewables sector, diligent planning may be required to ensure such an outcome. Moreover, others have shown that job losses can be quite localized given that fossil fuels and renewables do not typically occupy the same space (26). Additionally, there have been increased costs incurred by residential households in the renewable energy market.

In Germany, for instance, the exemption of privileged electricity consumers (industries) in 2015 from the German Renewable Energy Act EEG surcharge of 4.8 billion euros (107 TWh in electricity terms) increased the energy burden of other electricity consumers, particularly private households with energy intensive industries in turn, benefiting the most from the merit order effect (27).

In California, renewable-energy mandates and its carbon cap-and-trade program have created a regressive energy tax resulting in higher household electricity burdens (percent of household income spent on electricity bills). One implication of this was that in 2012, 1 million households in California faced energy poverty with several counties having household energy poverty prevalence rates as high as 15% (28).

In Australia (29), despite being a relatively new and marginal source of electricity, complaints have raised concerns about the equity of landowners and contracts for hosting wind farms. When contracts are perceived as unfair, social consequences can be severe, both in terms of fracturing support for the wind farm within the community as well as dividing the community in economic terms. There has also been concerns arising from consumers in Victoria paying as high as 21% more on average for energy (19).

Policy implications

Don't get us wrong. Expanding renewable electricity in most if not all countries *is* the right choice, especially when one considers the seriousness of climate change and the monumental and mounting costs of fossil fuels. There is also growing, compelling evidence that we can accelerate transitions in ways unimaginable a few decades ago, and acknowledgement that transitions are non-linear and can produce surprises and manifest unintended consequences (30). To this end, we propose three suggestions for future developments.

First, a sequential displacement model for the low-carbon energy transition offers opportunities to address justice concerns while acclimatizing to renewables (see Fig. 2). Rather than disruptive policies implemented without sensitivity to vulnerable groups, a sequential displacement can achieve significant CO_2 reductions while reducing electricity bills. For instance, it could capitalize on the benefits of natural gas and energy efficiency while moving more gradually to renewables while they continue to improve and become more affordable. Acknowledging the inherent geopolitical tensions its use creates, natural gas may offer an attractive initial displacement for coal (with significant environmental benefits), especially when its availability is within reach and methane leakage is controlled (31). Coupling these supply-side transitions with stronger demand-side programs to help retrofit houses and deploy more efficient-energy devices can prevent electricity bills from rising (32). Moreover, subsidising energy-efficiency initiatives especially for the poor and vulnerable and providing ample time for households and businesses to accrue significant savings may be a powerful motivator of broad support for subsequent transition initiatives.

Secondly, reconfiguring the existing energy landscape rather than an overhaul can achieve decarbonization as well as stability in the electricity sector. Greater hybridization between dominant carbon intensive energy systems and emerging innovations in storage and digitization (33) can support low-carbon energy transitions. For instance, the careful decoupling of coal power stations could begin with the integration of coal with carbon capture and sequestration (CCS) or with closed-loop biomass (see Fig. 3). High initial investment costs notwithstanding, the reconfigured energy systems still ensure that (1) any necessary electricity cost increment is not detrimental to consumers, (2) job losses (especially associated with non-transferrable skills) can be effectively minimized and adequately compensated, (3) system stability can be maintained, and (4) significant CO_2 emissions can still be achieved.

Finally, consumers still offer great potential for significant energy demand reduction in low-carbon energy transitions. As one tool to engage the consumer as a low-carbon agent, smart meters coupled with time-of-use tariffs, solar PV, and mobile (i.e., electric cars) and stationary storage – along with the suite of initiatives that support them – can facilitate both reductions in household consumption and an expansion of low-carbon supply. Similarly, the effective utilization of wind and solar can be enabled by the direct load control (DLC) of heating, ventilation, and cooling, and the bidirectional charging of electric vehicles.

Conclusion

Although critical of renewable energy policies and practices to some degree, we have not sought to dismiss the ambition of the low-carbon energy transition. Rather, our criticisms have a target in mind: create more equitable, egalitarian, and pro-poor low-carbon transition policies. Considering the likely irreversible momentum of variable renewable energy (34), we advise caution and a more people-centric approach. In formulating decarbonization pathways, policymakers must critically evaluate such policies to *ab initio* pre-empt likely and potential fall-outs and provide commensurate compensation for "losers".

Admittedly, our paper is the product of an international scan of renewable energy policies and data by experts in the field, identifying some common and concerning trends. It is not a modeling exercise with simulated counterfactuals or matched treatments and controls, but there is an underlying literature that the authors draw on and have contributed to, which provides robustness to our interpretations

While it may be infeasible to exhaustively determine unintended consequences of low-carbon energy transition pathways, fall-outs we contend must not emanate from irrational or short-sighted decisions. This we conclude is necessary in facilitating a *just*, result-oriented, and sequential low-carbon energy transition, one that does not cut carbon at the cost of the most vulnerable members of society.

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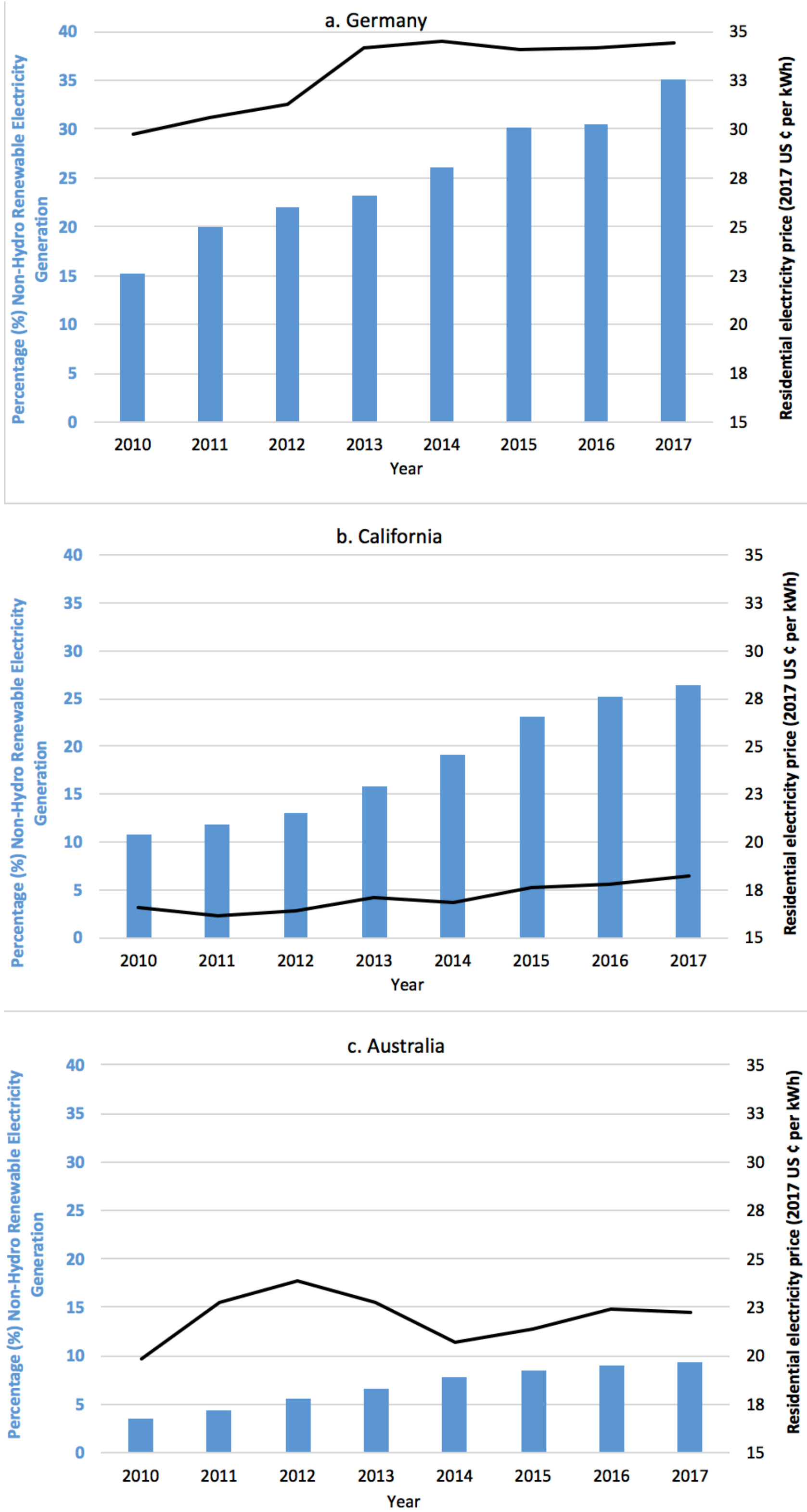
Figure 1: Non-hydro renewable electricity penetration (blue bars) and residential electricity prices (black lines) in 2010-2017. Sources: (1,23,35,36,37,38,39).



Notes: Price data for Australia are published by fiscal year; these are averaged across calendar years in the table for consistency across case studies.

Figure 2: Sequential displacement decarbonization strategy (VRE – Variable Renewable Energy)

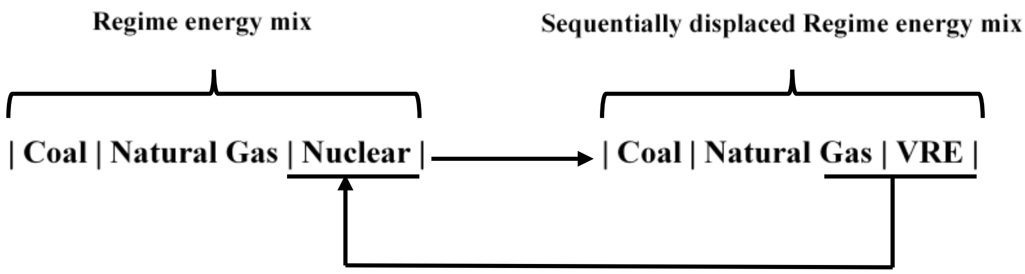


Figure 3: Hybridisation decarbonisation strategy