RethinkX

Disruption.
Implications.
Choices.

Policy Primer

Germany's Path to 'Freedom Energy' by 2030

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Germany is facing an unprecedented energy supply crisis as it rethinks dependence on Russian oil and gas imports. *But this crisis also poses a unique opportunity*. Within the next decade, Germany can lead the world by creating a fully self-sufficient zero cost clean energy system for less than the country's current annual fossil fuel spending, laying the foundations for a bold new era of long-term energy security and economic prosperity unlike anything seen before.

- By accelerating the solar, wind, batteries (SWB) and electric vehicle (EV) disruptions, Germany can meet all its energy needs across electricity, transportation, and commercial and residential heating by 2035, with no need to build more conventional energy or hydrogen capacity. Once built, this system will free Germany of the need for any further spending on fossil fuel imports contributing to savings equivalent to around a hundred billion dollars a year for decades based on 2021 data.

- This new clean energy system does not represent a one-for-one substitution of the old system and cannot be understood through the lens of the conventional energy paradigm. The new energy system will have different dynamics and properties than the existing system. It represents a complete phase transformation in the energy system, that is truly self-sufficient, stable and secure. It will also pave the way for unprecedented prosperity by generating 5 times the amount of Germany's current electricity demand at zero marginal costs for most of the year, in effect enabling Germany to generate virtually free energy with no dependence on external actors.

- Just as the internet and smartphone disruption of print news led to a completely new zero marginal cost information system leading to new business models and extraordinary wealth creation opportunities across the economy, zero cost energy will create a completely new type of energy system with fundamentally distinctive properties that will utterly transform the global economy as we know it. This is a revolutionary transformation from a system based on scarce atoms and molecules, to one of limitless photons and electrons.

- Instead of a scattershot 'all of the above' approach, this is a simpler strategy focusing on a handful of already existing key technologies that will transform the entire foundation of our economy. But simple does not mean easy. Simple means understanding the key drivers and levers of major systemic change. We do not need to rely on hoped for 'breakthrough' or 'miracle' technologies that are not mature today, but to focus on accelerating costs and capability improvements in these existing technologies. Instead of onerous state intervention, this requires leveraging markets by unleashing entrepreneurial drive to accelerate new business models and product innovations for the emerging clean energy system.

Background

The key to meeting the current challenge is to fully understand technology disruption, its geopolitical implications and its race-to-the-top consequences.

In 2014, in his book *Clean Disruption of Energy and Transportation*, RethinkX co-founder Tony Seba predicted how exponential cost declines and performance improvements in solar, wind, and batteries (SWB) as well as electric and autonomous vehicles (E-AVs) would inevitably disrupt the energy and transportation sectors within the next two decades. This is now happening.

Seba and fellow co-founder James Arbib met each other for the first time at a US military think tank in 2016, where they warned military leaders that these disruptions would reduce demand for fossil fuels, causing volatility and instability that would set the scene for Russian aggression (both external and internal) in the early 2020s. The realization that the world was not preparing for the scale of technology disruptions to come in the 2020s led Seba and Arbib to co-found RethinkX. This think tank published as its first report an analysis of the implications of the existential threat that a disruption to the internal combustion engine from electric vehicles might pose to the oil industry.

As of 2020, the world is now past the rupture point where fundamental change becomes inevitable, for both the energy and transportation disruptions, as disruptive technologies become increasingly cheaper than the incumbent industries. Societies now face a bifurcation point into the new emerging system – they can either adapt and rise to the top by harnessing the technology disruptions, or resist them resulting in decline and collapse.

Research Highlights

1. Solar, wind and batteries (SWB) are on track to become 70% cheaper than conventional energy over the next decade. Disruption of the energy sector by SWB and disruption of the transportation sector by electric and later autonomous vehicles (E-AVs) is therefore unstoppable within 10 years purely due to economic factors, meaning SWB offers the fastest path to transformation by leveraging markets. However, this process can be delayed or accelerated by societal choices.

2. Self-sufficiency and independence of Germany's existing electricity demand is achievable by accelerated disruption at a total cost of $367 billion over 10 years, equivalent to just $36.7 billion a year, which is less than Germany's current annual fossil fuel subsidies of around $41 billion, and less than 1% of Germany's GDP in 2020.

3. Total self-sufficiency and independence of Germany's energy in electricity, transportation, and commercial and residential heating is achievable by accelerated disruption at a total cost of $1.47 trillion over 10-15 years, eliminating any need for new conventional energy investments or hydrogen.

4. These are all one-time costs. If the largest investment is spread annually from now to 2035, it will amount to a yearly spend of $113 billion. This is 2.9% of Germany's GDP: less than what Germany is estimated to have spent in total ($121 billion) on oil and gas imports and fossil fuel subsidies in 2021, and less than its 2020 Covid stimulus spending. Once the new system is established, it will generate enormous free surplus energy, eliminating dependence on continued fossil fuel spending. This means that after 2035, this system will generate trillions of dollars of savings over ensuing decades.

5. Our assumptions are based on market-driven investments. However, should the government decide that this is an existential crisis that necessitates the government to fund the costs of this system, it would provide the German economy with a huge competitive advantage for less than Germany's current fossil fuel spending.

6. These clean technology disruptions represent a race-to-the-top. They will enable Germany to simultaneously achieve energy independence (with associated geopolitical benefits), energy decarbonization (with associated climate change benefits), and zero cost energy superabundance (with associated economic benefits) without trade-offs.

Policy Recommendations

1. Commit to 100% solar, wind and battery electric energy infrastructure by 2030 and the whole energy system by 2035. Provide clarity on goals, challenges and resources the state will marshal to make this happen.
2. Stop all non-emergency subsidies and other supports for incumbent energy industries but temporarily and strategically prop up existing conventional generation while the new SWB system is being built.
3. Design free, open and transparent energy markets at all levels.
4. Guarantee the right for individuals to generate, store, and trade electricity through an 'Energy Bill of Rights'.
5. Focus major government intervention on electrification of residential and commercial heating and cooking.
6. Protect people, not industries.

In-Depth

German finance minister Christian Lindner has said, 'Renewable energy is freedom energy', and Germany has taken the extraordinary step of bringing forward its net-zero renewable energy targets, aiming to meet all its electricity needs from solar and wind sources by 2035, and spending $216 billion over the next four years. However, our preliminary analysis reveals how Germany can go much further, achieving complete electricity self-sufficiency as early as 2030, and whole energy self-sufficiency as early as 2035.

1. Disruption of the energy sector by solar, wind, and batteries (SWB) and disruption of the transportation sector by electric and autonomous vehicles (E-AVs) is inevitable within 10 years.

The same pattern of disruption has occurred many times throughout human history. For technologies of all kinds – from cars to carpenter's nails, from arrowheads to automatic braking systems, from insulin to smartphones – we see that as costs of new technology fall, adoption follows an s-curve over the course of just 10-15 years. The first phase of the s-curve is characterized by accelerating (or exponential) growth, driven by self-reinforcing feedback loops that make the new technology increasingly more competitive while simultaneously making the old technology increasingly less competitive.

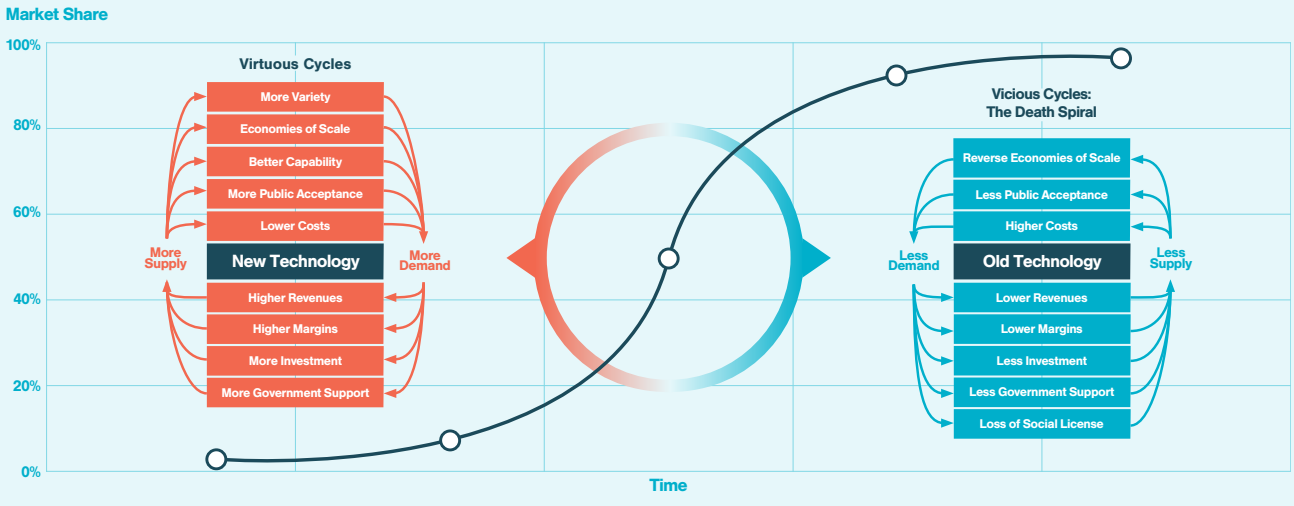
Today, solar power, wind power, batteries, and electric vehicles are all following exactly this same pattern of disruption. We should therefore expect the bulk of this process to take place in the 2020s and be complete in the 2030s.

A major misconception about disruption is that a new technology will simply be a like-for-like substitution of the old, without otherwise changing their industry, sector, or society. This does happen in some disruptions, but in many cases we experience a 'Phase Change Disruption'. In this case a totally new system emerges. As Buckminster Fuller noted: "There is nothing about a caterpillar that says it is going to be a butterfly".

Technology disruptions can cause a phase change, entailing a fundamental shift of the system into an entirely new configuration. New business models, new modes of value creation, new markets, and most of all a whole new possibility space for society and the economy emerge that could not exist before – and often could not even be imagined. The car was not just a faster horse. The car was a phase change, not just in transportation but everything from housing to war to geopolitics in the twentieth century. The Internet is a recent example of such a phase change. Computers did not just substitute for typewriters and pencils, but instead the superabundance of near-zero marginal cost information and communications allowed an entirely new system to emerge that has deeply affected every aspect of human life.

What happened in the world of bits is now poised to happen in the world of electrons. The SWB energy disruption has similar properties of superabundant near-zero marginal cost electricity, and therefore also represents a phase change that will lead to an entirely new energy system, with profound implications and possibilities. It is essential that policymakers, investors, civic leaders, and citizens in Germany understand disruption so the country can prepare for the extraordinary opportunities ahead.

Figure 1. The Pattern of Disruption



2. Independence and self-sufficiency of Germany's existing electricity demand is achievable by accelerated clean energy disruption at a total cost of $367 billion over 10 years.

Our research shows that many different combinations of solar power, wind power, and batteries can meet 100% of Germany's roughly 500 terawatt-hours of electricity demand. But some are more costly and slower to deploy than others. RethinkX created the 'Clean Energy U-Curve' as an analytical tool for identifying the lowest cost combination of SWB. The Clean Energy U-Curve reveals that for all regions, overbuilding generating capacity several times that of existing demand dramatically reduces battery storage requirements, and therefore dramatically reduces the overall costs of the system while getting through the darkest days of winter. It also shows that additional investments in SWB result in extremely large increases in generating capacity. This enables a huge surplus in electricity generation produced at zero marginal costs for most of the year.

All SWB systems will therefore produce a surplus of electricity because their capacity must be built to meet demand during Dunkelflaute, the times when sunshine and wind are least available. As this surplus electricity from solar and wind power is clean and overall has near-zero marginal cost, RethinkX refers to it as 'clean energy super power' or simply 'super power'.

In Germany, the lowest-cost SWB system meeting all of Germany's electricity demand will produce an additional 130 terawatt-hours of super power each year. However, the returns on SWB capital investment are extremely large, dramatically changing the economics of energy. An additional 20% investment above the lowest-cost configuration increases super power by 375%, to 615 terawatt-hours per year.

History shows that energy abundance enables social and economic development in the broadest sense. A superabundance of cheap, clean energy will be transformative throughout the economy and society of Germany. Potential applications for super power include water desalination and treatment, waste processing and recycling, metal smelting and refining, chemical processing and manufacturing, cryptocurrency mining, distributed computing and communications, and carbon removal – to name just a few. For instance, auto makers could save hundreds or even thousands of dollars per vehicle manufactured.

Figure 2. The Clean Energy U-Curve for Germany

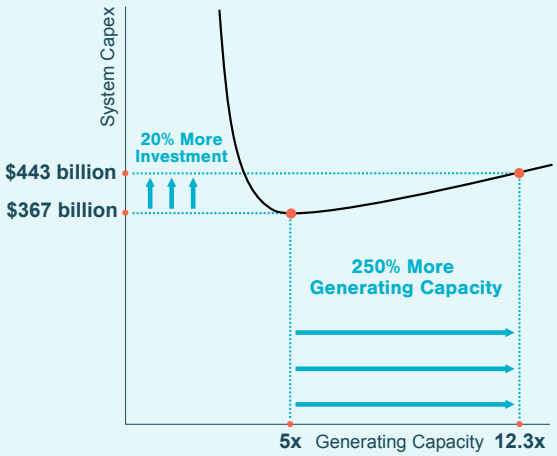


Figure 3. Super Power for Germany

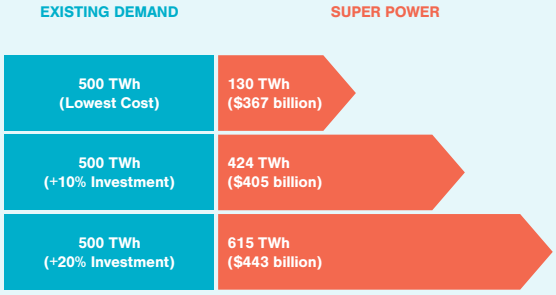


Figure 4. 100% SWB Electricity Systems in Germany

	Lowest-Cost 100% SWB System	Lowest-Cost 100% SWB System +20% Additional Investment
Capital Cost	$367 billion	$443 billion
Solar PV Capacity	210 GW	770 GW
Wind Capacity	180 GW	180 GW
Generation Capacity	5.0x	12.3x
Battery Capacity	6221 GWh	3340 GWh
Super Power	130 TWh	615 TWh
Fraction of Days with Super Power	47%	88%
Electricity Cost (0% of Super Power utilized)	$0.097 kWh	$0.117 kWh
Electricity Cost (50% of Super Power utilized)	$0.086 kWh	$0.073 kWh
Electricity Cost (100% of Super Power utilized)	$0.077 kWh	$0.053 kWh

3. Independence and self-sufficiency of Germany's energy in electricity, transportation, and commercial and residential heating is achievable by accelerated clean energy disruption at a total cost of $1.47 trillion over 10-15 years.

Going beyond Germany's existing electricity demand of about 500 terawatt-hours, SWB can disrupt all forms of energy use throughout the country. Our preliminary analysis of a 100% Clean Energy Germany scenario indicates that the country can eliminate all fossil fuel use in electricity generation, residential and commercial heating, and road transportation by building 900 gigawatts of solar capacity, 600 gigawatts of wind capacity, and 9867 gigawatt-hours of battery capacity.

This clean energy system would temporarily retain the country's existing 61 gigawatts of nuclear power and 18 gigawatts of hydropower as baseload, as well as gas peaking generator capacity while the new system is being built. It would also temporarily invest in efficiency improvements (e.g. heat pumps, insulation, smart metering, etc.) to reduce energy requirements for heating while the new system is being built.

The capital expenditure requirement for this 100% Clean Energy Germany scenario is $1.47 trillion over 10-15 years, which by 2035 translates into an annual spend of $113 billion, less than Germany's spending on fossil fuel imports and subsidies in 2021. In 2021, Germany spent $79.9 billion on oil and gas imports. Some estimates suggest that Germany spends $41 billion annually on fossil fuel subsidies. This suggests it spent as much as $120 billion. After 2035, with the whole energy system generating enormous free surplus energy, Germany will therefore make hundreds of billions if not over a trillion dollars of savings every decade.

In this scenario, Germany's new 100% SWB system will generate 1636 TWh of super power in addition to displacing existing German electricity demand of 500 TWh, and contributing to new demand of 510 TWh that will supply heat and transport. This means that the new system will overall generate an astonishing 5 times the quantity of current demand. This clean energy wealth is the foundation for societal wealth.

The investment costs identified here are one-time capital costs to build out this system. Once built the vast bulk of the energy generated will be produced at zero-marginal costs – effectively for free. Cheap superabundant energy will in turn dramatically transform Germany's economy and industrial capabilities, generating unprecedented economic and social benefits while opening up a vast array of new business models.

This SWB scenario in particular means that no new construction of nuclear power, hydropower, geothermal energy, or hydrogen capacity or infrastructure is required. Therefore, it is the fastest, cheapest and safest scenario by which Germany can achieve not just total energy self-sufficiency and security for rest of the century, but also the foundations for unprecedented prosperity. No 'energy breakthroughs' or 'energy miracles' are needed.

Figure 5. Largest Super Power Scenario in Germany

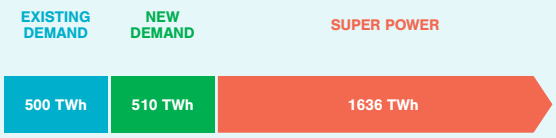


Figure 6. RethinkX '100% Clean Energy Germany' Scenario

Capital Cost	$1.47 trillion
Solar PV Capacity	900 GW
Wind Capacity	600 GW
Generation Capacity	19.2x
Battery Capacity	9867 GWh
Super Power	1636 TWh
Fraction of Days with Super Power	92%
Electricity Cost (0% of Super Power utilized)	$0.198 kWh
Electricity Cost (50% of Super Power utilized)	$0.109 kWh
Electricity Cost (100% of Super Power utilized)	$0.076 kWh

4. Technology disruption represents a race-to-the-top because energy independence (with associated geopolitical benefits), energy decarbonization (with associated climate change benefits), and energy super abundance (with associated economic and social benefits) can all be achieved simultaneously without trade-offs with these clean technologies.

The energy disruption is not a one-for-one substitution. It represents a complete phase transformation that will create an entirely new energy system with new properties and possibilities. As we are now past the rupture point, the disruptive technologies will become exponentially cheaper than the incumbents, leaving societies, governments and companies with a stark choice: either adapt and rise; or resist and decline.

The Russia crisis has, therefore, created an unprecedented opportunity for Germany to play a leading role in this phase change. As SWB begins to disrupt energy and EVs begin to disrupt transportation, the new system that emerges will create extraordinary opportunities, especially for pioneering regions and countries that choose to embrace and accelerate the disruptions. A race-to-the-top dynamic will emerge as those countries that first encounter and solve the challenges posed by this transformation will create the world-leading knowledge, technologies and industries both within the energy sector and across all industries that are impacted as a consequence.

The only path to achieve energy independence, decarbonization and superabundance simultaneously without trade-offs is through SWB and A-EV clean technology disruption. A holistic, integrated vision is essential to enable optimal decision-making during the current crisis. Germany can choose to transform itself and lead the world, and in doing so it can realize the enormous benefits of innovation, influence, job creation, and general prosperity that we have seen leading regions capture during other phase changes of the past such as the Internet.

Policy Recommendations

RethinkX offers the following policy recommendations for accelerating the disruption of energy and transportation in Germany and charting a path to 'freedom energy' for independence, decarbonization, and abundance.

1

Commit to 100% solar, wind and battery electric energy infrastructure by 2030 and the whole energy system by 2035. Provide clarity on goals, challenges and resources the state will marshal to make this happen.

German energy independence will be a major effort, akin to a moon-shot or even war. It will require the German government to commit to clear goals and timelines, define challenges to be overcome and what resources it will bring to bear in accomplishing those goals. RethinkX recommends that the government should commit to the goal of 100% SWB infrastructure to displace current electric power demand by 2030 and the whole energy system by 2035.

These goals should be clear. Metrics tracking those goals should be publicly and constantly updated. Clarity would accelerate market investments and participation in creation of new products and services. It would help in creating public excitement that every solar panel installed, every EV acquired and every induction oven installed, makes a difference. It would spark widespread optimism that would help workers in old industries transition to the new industries.

The government should communicate clearly and succinctly that this is a phase transformation of the old system and support efforts to imagine what the new system would look like. This is a move away from atoms and molecules to photons and electrons. The government should resist investing in band-aids that promise to substitute the energy system with a 'cleaner' conventional system. This would be the modern equivalent to a 'faster horse syndrome'. 'Cleaner fuel syndrome' (hydrogen, biogas, biofuels) are losing strategies just like 'Clean Coal' and 'Clean Diesel' were losing strategies in the past. If it needs a pipeline or cave storage, it is part of the incumbent energy system that is bound to be disrupted.

It is also important to communicate clearly what the challenges to overcome are. Some things will get worse before they get better. Increasing coal production will increase pollution. Keeping nuclear plants online for longer than previously promised will mean living with the specter of meltdowns for a few more years. The government should commit to closing these plants as soon as the new SWB system can generate and store enough energy to make them unnecessary. This is akin to creating a clear and public 'dirty energy smart contract' that is automatically enforced after a committed timeframe or when the new SWB infrastructure achieves an agreed minimum threshold. Germans will pay a 'dirty premium' for a few more years.

2

Stop all non-emergency subsidies and other supports for incumbent energy industries but temporarily and strategically prop up existing conventional generation while the new SWB system is being built.

In the current crisis, it may be necessary to undertake emergency subsidies and other supports for incumbent fossil fuel industries as temporary measures to obtain national energy security while Germany ends its dependence on Russian oil and gas imports. These temporary measures may include expansion of LNG imports, expansion of coal production, bringing closed coal power plants back online, and postponing nuclear power plant closures.

However, it is extremely important that Germany builds time limits into these subsidies and supports from the start, and resists calls from incumbent industries to use such measures as 'bail outs' to extend their life-span beyond what is absolutely necessary. No new capital investment for conventional energy based on atoms and molecules are necessary. These are strategic, temporary measures, not multi-decade investments. More permanent 'stop-gap' measures can include investing heavily in reducing demand through heat pumps and other energy efficiency measures.

'Freedom Energy' requires that Germany break its dependence on all fossil fuels, not just those imported from Russia. Therefore, Germany should seek to rapidly end generalized subsidies for fossil fuels across their entire value chain, which some estimates claim to be as high as $41 billion per year. These funds and all other new energy investments can instead be focused entirely on building out the new SWB clean energy system.

While RethinkX recommends removing large government subsidies for incumbent industries, we do not recommend that they must necessarily be replaced by new subsidies for SWB. Instead, with genuinely free and fair electricity markets, the economic dynamics driving SWB adoption will in themselves generate the incentives for the required public and private sector investments. Additional state subsidies are not necessary, but instead can be used strategically to support and incentivize these investments.

RethinkX also does not recommend a carbon tax, because the cost of SWB has fallen dramatically and will continue to decline in the 2020s. Now the inherent competitiveness of SWB alone will ensure that they attract public and private investment and are adopted exponentially, so long as electricity markets are free, competitive and transparent at all levels.

3 Create free, open and competitive energy markets.

Because the disruptions are being driven by fundamental economic factors, they do not require excessive subsidies but can be accelerated by ensuring that markets operate properly. In other words, Germany can accelerate 'Freedom Energy' by ensuring free and open energy markets.

The SWB disruption can be accelerated by removing existing market barriers, interventions, and inefficiencies. These new technologies are already competitive under open market conditions, but large subsidies and regulatory supports for fossil fuels have distorted electricity markets in favor of centralized utility monopolies that have strong incentives to delay SWB deployment and disruption.

4 Guarantee energy rights for all through an 'Energy Bill of Rights'.

'Freedom Energy' requires that all individuals, communities, and companies be free to generate, store and trade electricity with anyone else, in an Internet of Energy that uses photons, electrons and bits, instead of just bits. Today, many who wish to do so cannot access energy markets fairly, if at all.

Free and open energy markets cannot function properly or unleash the full potential of SWB if anyone is excluded from participation. Because SWB can be deployed at any scale, from residential rooftops to gigawatt-level installations, these technologies are inherently democratic and decentralized.

It is particularly important that individual households and companies have the right to own distributed energy resources (DER) and utilize them on the markets to support the disruption of fossil fuels in transportation by A-EVs.

An Energy Bill of Rights will therefore recognize the rights of individuals and businesses to generate, store, and trade electricity, in a similar way that we have the right to generate, store, and trade information. Under this Bill of Rights, governments should not tax SWB self-generation. This approach will bring free market capitalism to electricity at all levels, which will accelerate electrification (and disruption of fossil fuels) at all levels. It will accelerate adoption of electric vehicles that can be used to power homes and participate in trading and stabilizing the grid. A 200-mile EV could supply several days of power demand for the average German home. It will also accelerate the electrification of heating and cooking.

5 Focus major government intervention on electrification of residential heating and cooking.

German government intervention and capital outlays should focus on areas where there are high barriers to change even with the right market signals. This means supporting the electrification of residential heating and cooking, where lack of standards and plug-and-play solutions make it difficult and relatively expensive to move away from fossil gas to electric heating, cooking, and so on.

Government support must include accelerating the development of appropriate standards for plug-and-play home electric grids that include solar, stationary batteries, electric vehicles, electric space heating and induction cooking. German standard setting and early adoption could power a new global industry that would do to electrons what Silicon Valley and the internet did for bits.

6 Protect people, not industries.

It is also crucial that emergency subsidies and supports focus on people rather than industries. Workers displaced by the crisis and disruption should be protected, but fossil fuel companies and organizations should be allowed to dissolve.

Regardless of German government policy decisions, SWB is poised to displace incumbent energy industries purely due to economic factors. RethinkX research demonstrates that conventional energy assets are already stranded, and will therefore not sustain hoped for returns. This means that expenditures designed to prolong the life of these industries will be counterproductive.

Instead of seeking to protect industries that are bound to be replaced over the next decade, the government should focus on a plan to wind down incumbent industries that will facilitate the movement of people and expertise into the rapidly deploying clean energy system. Studies show that the clean energy disruption is on track to generate a larger number of jobs than incumbent industries. As the amount of electricity will more than triple and much of the country's fossil fuel infrastructure is electrified, the number of electrical engineers and electrical contractors needed to enable this transformation will likely grow accordingly.

It is essential that the government have programs in place to help people transition from the collapsing fossil industries to the booming electrification industries. Vast amounts of zero marginal cost energy can also make existing industries like car manufacturing which use large amounts of energy more competitive while also creating new industries based on products and services that were not possible within the legacy conventional energy system.