Summary from an International Perspective

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1. At its core, the *Energiewende*—the German energy transition (in the electricity sector)—is a political and, given its long-term design, a social project defined by desired characteristics of the German electricity system in 2050:
   1. No nuclear energy—from a 23% share in electricity generation in 2010
   2. (At least) 80% share in electricity generation—from 17% in 2010
   3. Electricity efficiency = approx. 8 €/kWh—from approx. 4 €/kWh in 2010.
2. This target state in 2050—in particular targets 1 and 2—is an inevitable consequence of the three main underlying motives of the German energy transition:
   I. Drastic reduction of CO_2 emissions
   II. Phase-out of nuclear energy
   III. Reduction of dependence on (foreign) fossil fuels.

   There is a very broad and solid consensus in the German political landscape and in German society on these motives, especially I and II.
3. Motives I and III are essentially shared by most countries all over the world, though with quite different priority on their respective political agendas. Motive II, however, is largely unique to Germany.

   The Paris Climate Agreement of 2015 gave an important global push for motive I and must entail—when taken seriously—fundamental energy transitions in many countries.
4. In addition to the target state in 2050, the *Energiewende* design comprises a number of important milestones, primarily:
   – Shutdown of the last nuclear power plant in 2022
   – RE share of (at least) 50% in electricity generation in 2030.

   While the target state 2050 is conceptually inevitable in light of the underlying motives, this is not true of the milestones: They contain a considerable degree of political arbitrariness. The milestones set out an unnecessarily high speed for the *Energiewende*, which in turn makes it unnecessarily expensive (see Chap. 12).

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5. A fundamental inconsistency in the German energy transition concept is the almost exclusive focus on the German energy system, even though the CO_2 issue is, by its very nature, a global challenge and the German contribution to global CO_2 emissions is only around 2%.

   Accordingly, a rational climate policy for Germany and for any developed country should focus a considerable part of its attention and financial resources on reducing CO_2 emissions *in other countries*, especially developing countries and emerging economies. It is likely that thereby significant CO_2 reduction potentials can be tapped more cost-efficiently and more quickly. (In return, the speed of energy transition in the own country can be somewhat reduced.)
6. In addition to its immediate targets and underlying motives, Germany's *Energiewende* policy sets out to comply with three basic principles or framework conditions:
   - Safeguard security of supply (as far as possible).
   - Insist on cost-efficiency and ensure affordability of electricity (as far as possible).
   - Preserve market economy in electricity generation (as far as possible).

   While the targets and motives of the *Energiewende* are largely undisputed in German politics and society, the proper application of these principles to the specific implementation of the *Energiewende*—i.e. proper application of the framework conditions in current decisions on energy politics—has repeatedly been the subject of intense political debate and social discussion.
7. These three principles certainly represent framework conditions for the energy policy in many other countries as well. Nevertheless, their weighting (also in relation to each other) and their practical application are likely to lead—in the context of the energy transitions to be expected around the world (see item 3)—to energy policies which will differ considerably from country to country.
8. Taking the targets, motives and framework conditions of the *Energiewende* as a basis, then—consistent implementation provided—essential characteristics of the future electricity system in Germany are already defined:
   - Wind and sun as the primary pillars of electricity generation
   - Large new power lines from generation sites to consumption centres
   - New energy infrastructure (especially storage) and new control systems to handle the high temporal volatility of wind and sun
   - Significantly higher fragmentation, decentralization and diversity of stakeholders than in the previous electricity system.

   On the one hand, these systemic consequences largely depend on the specific circumstances in Germany:
   - Natural conditions for hydropower and biomass
   - Natural conditions for PV and wind power (in particular, hours of use for PV systems and wind plants)
   - Distance of the centres of electricity consumption to the regions with most favourable conditions for PV and wind

- Density of population
- Possibility of synergies with neighbouring countries
- Characteristics of the conventional power plant fleet
- Characteristics of the existing power grid
- And others.

On the other hand, it is probably safe to say that most countries—at any rate, most comparable countries in terms of economic development—will have to face at least some of these systemic consequences to some extent in an energy transition project, regardless of their particular conditions.

9. Within these essential contours of the future electricity system in Germany, many features are not determined yet as of today, i.e. they depend on future developments in technology, costs of technologies, economic opportunities and social preferences:
   - Shares of PV vs. wind (on) vs. wind (off) in electricity generation
   - The extent and technologies of storage facilities
   - The extent and nature of demand-side management (DSM)
   - Market rules for electricity generation, in particular for the remaining fossil fuel-fired power plants
   - The technologies of electricity applications for heating and transportation purposes
   - Mix between decentralized and central infrastructure elements
   - And others.

   With respect to these open questions along the further implementation path of the *Energiewende*, in most cases there will be different conceivable options for political regulation. Due to this fact and due to the diversity of stakeholders in the future energy economy with widely differing interests, the consistent political governance of the *Energiewende* in a democracy is and will continue to be a quite challenging task.
10. The predetermined characteristics of a mostly RE-based ("decarbonized") electricity system and the unanswered questions and unresolved challenges are likely to be of considerable relevance in other countries as well—regardless of whether their individual electricity system includes nuclear energy or not. Although the specific answers to these pending issues will be different in detail from country to country, the similarities and the intense efforts already seen around the globe to develop new energy technologies do present manifold opportunities for political, scientific and economic exchange between the nations of the world on the subject of energy transitions.