Institute of Engineering Thermodynamics

A balanced electricity mix – the role of system costs and material requirements in renewable energy systems

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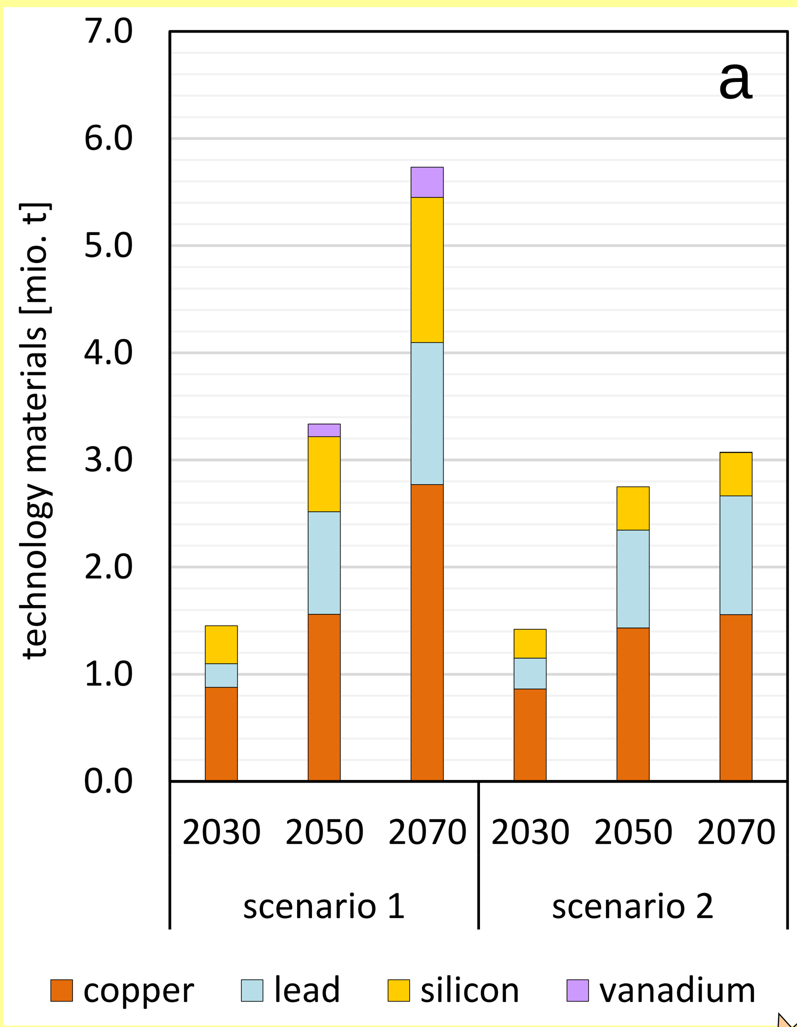
The implementation of a sustainable energy system with low costs and low material requirements is an important step to a sustainable energy system. The deployment of renewable energy (RE) plants is related to a low consumption of resources during operation but higher consumption of non-energy resources during the construction. Furthermore a wider base of materials is required in these applications. The used materials can be divided into the categories shown in **table 1**. On the one hand bulk materials **(figure 1, c-f)** can be considered as widely available, whereas the deployment of speciality materials used in thin-film photovoltaics and direct drive generators will depend on market dynamics and material substitutes. Therefore the main focus of the material requirements assessment will be on the technology materials **(figure 1, a+b)**, which are necessary for the functionality of a sustainable electrical energy system.

Technology materials *figure 1, a+b*	Materials required for the functionality of technologies	• Copper • Lead • Silicon • Silver • Lithium • Vanadium
Bulk materials *figure 1, c-f*	Materials required for structure and support, as well as materials required in large quantities	• Concrete • Steel • Aluminium • Glass
Speciality materials	Materials required for deployment of sub-technologies like thin-film photovoltaics and direct-drive generators	• Indium • Gallium • Cadmium • Tellurium • Neodymium • Dysprosium

Table 1 Classification of materials required for a sustainable electricity supply system

Definition: a balanced electricity mix consits of two complementary technology classes to about equal shares: fluctuating and dispatchable energies.

This approach has been applied as a case study to the German electricity supply system. The compared system includes one scenario based on high shares of domestic resources, such as wind and photovoltaics (scenario 1), while the other includes imports of renewable dispatchable energy produced by concentrated solar power plants (CSP) located in North Africa (scenario 2). Both scenarios (**figure 2)** include the current political goals towards 50 % share of renewable energies in 2030 which is increased to 80 % in 2050 but also 95 % in 2070 respectively. The resulting material needs **(figure 1)** show an exponential growth in scenario 1 and a saturated curse in scenario 2 with additional electricity imports from CSP with significant lower use of materials. Thus import dependencies of materials can be reduced and a potential pricing pressure with the concurrent use of materials in other sectors will be eased. Temporally material bottle necks in scenario 1 may occur especially mining silver and lithium.



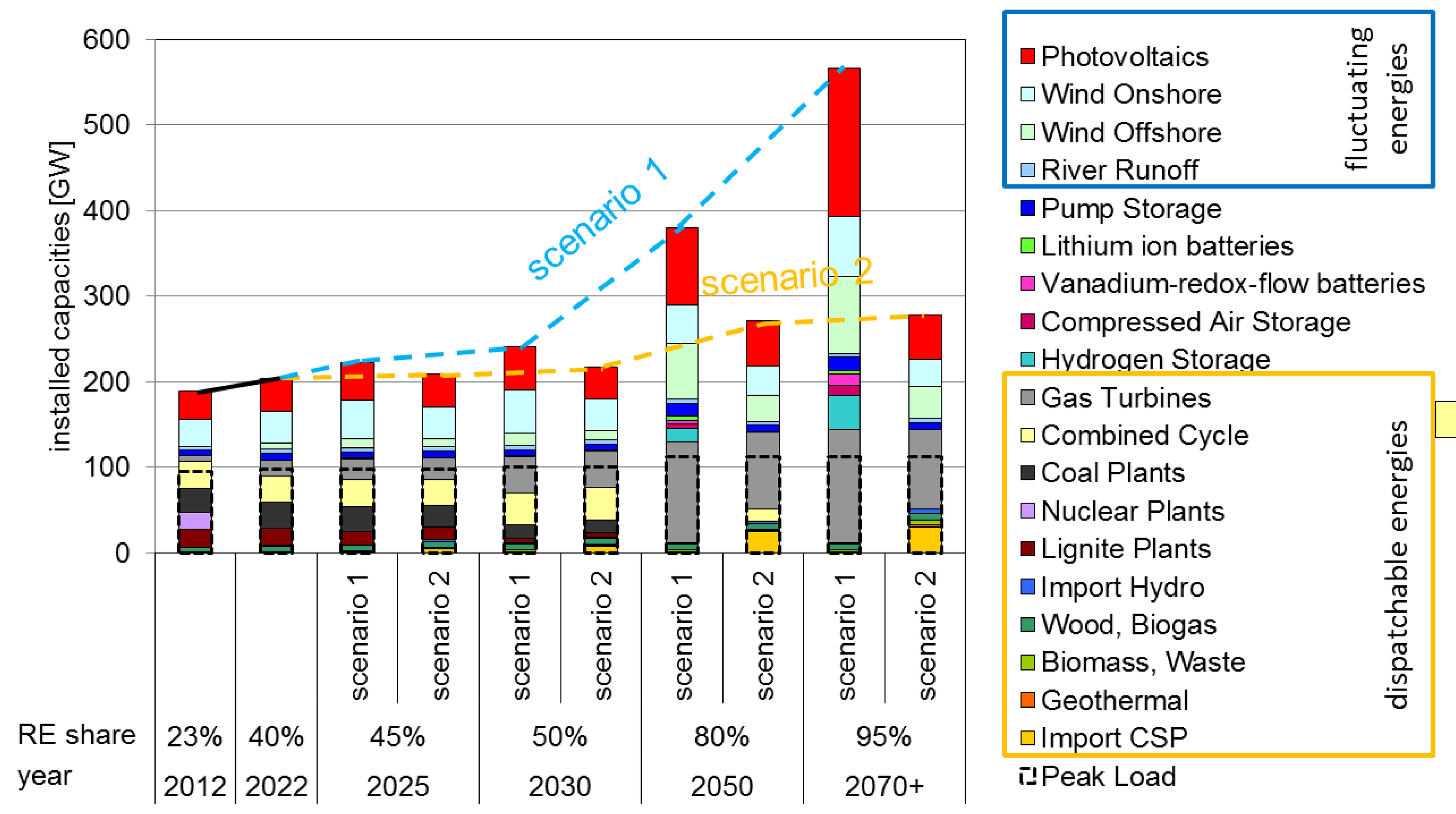
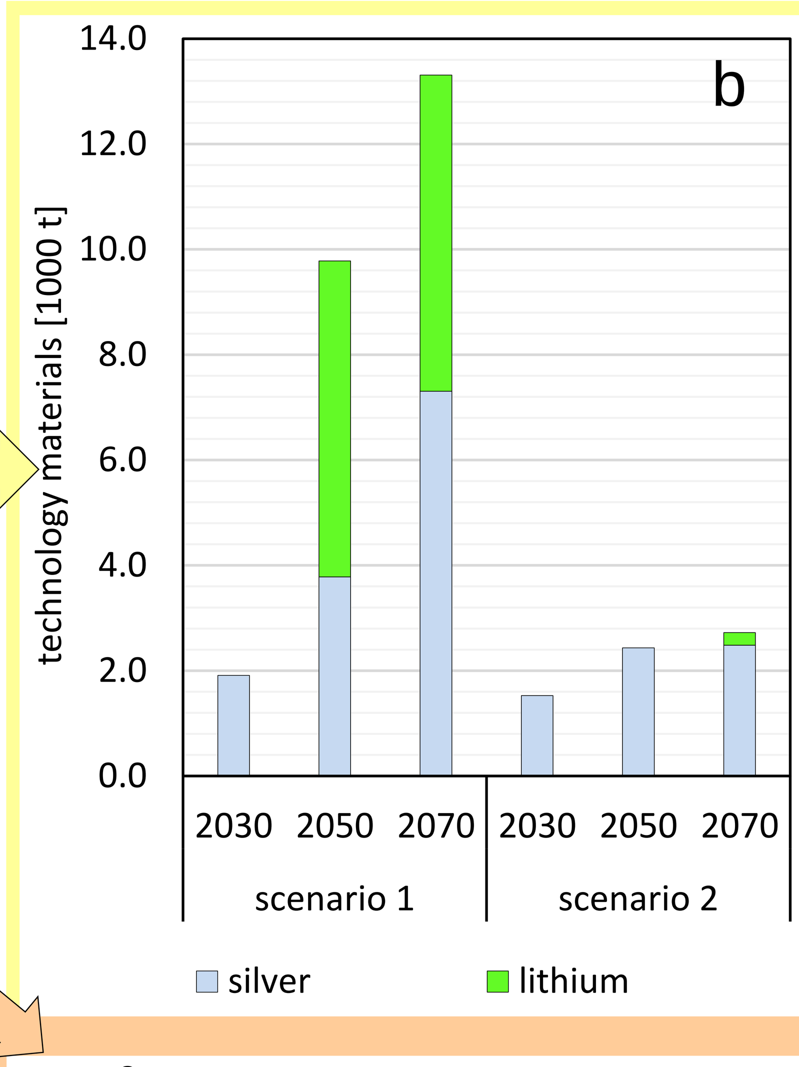


Figure 2 Two scenarios of the development of the installed capacity in the German electricity supply system, without electricity imports of dispatchable concentrating solar power (1) and with CSP (2)



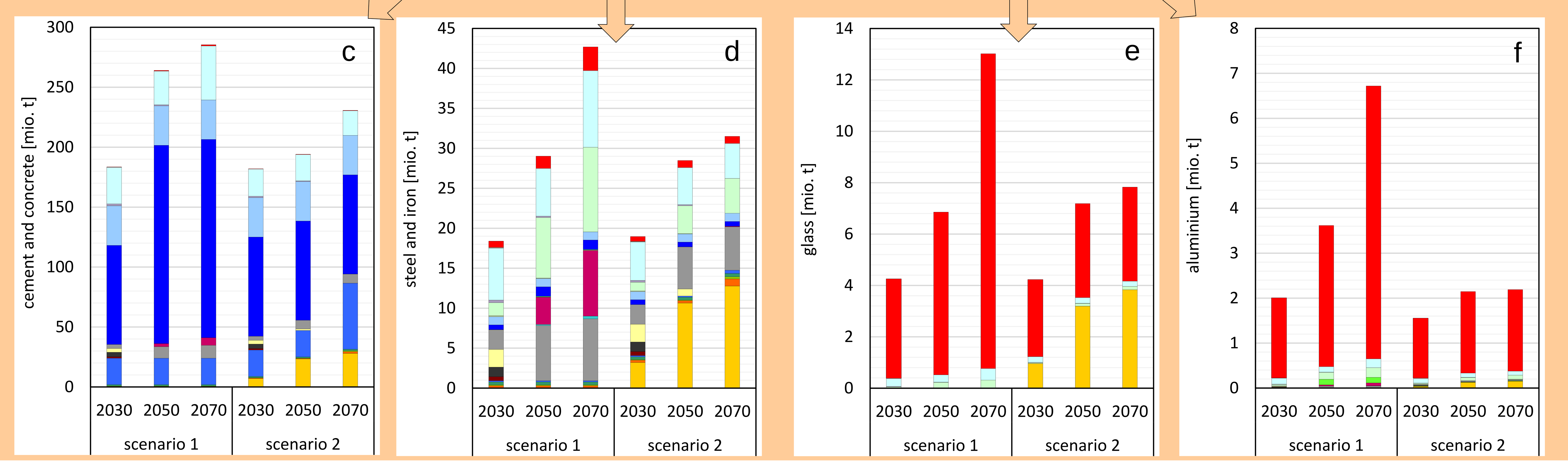


Figure 1 Technology materials copper, lead, silicon and vanadium (**a**), silver and lithium (**b**); Bulk materials: cement and concrete (**c**), steel and iron (**d**), glass (**e**), aluminium (**f**)

Outlook: Global scenarios could identify bottle necks of material supply. This may lead to the identification of potential material substitutes. The consideration of learning curves and their cost effects can therefore be strongly influenced when materials are scarce goods. Furthermore the ecological impact of resource extraction will be a high influence on the degree of sustainability.

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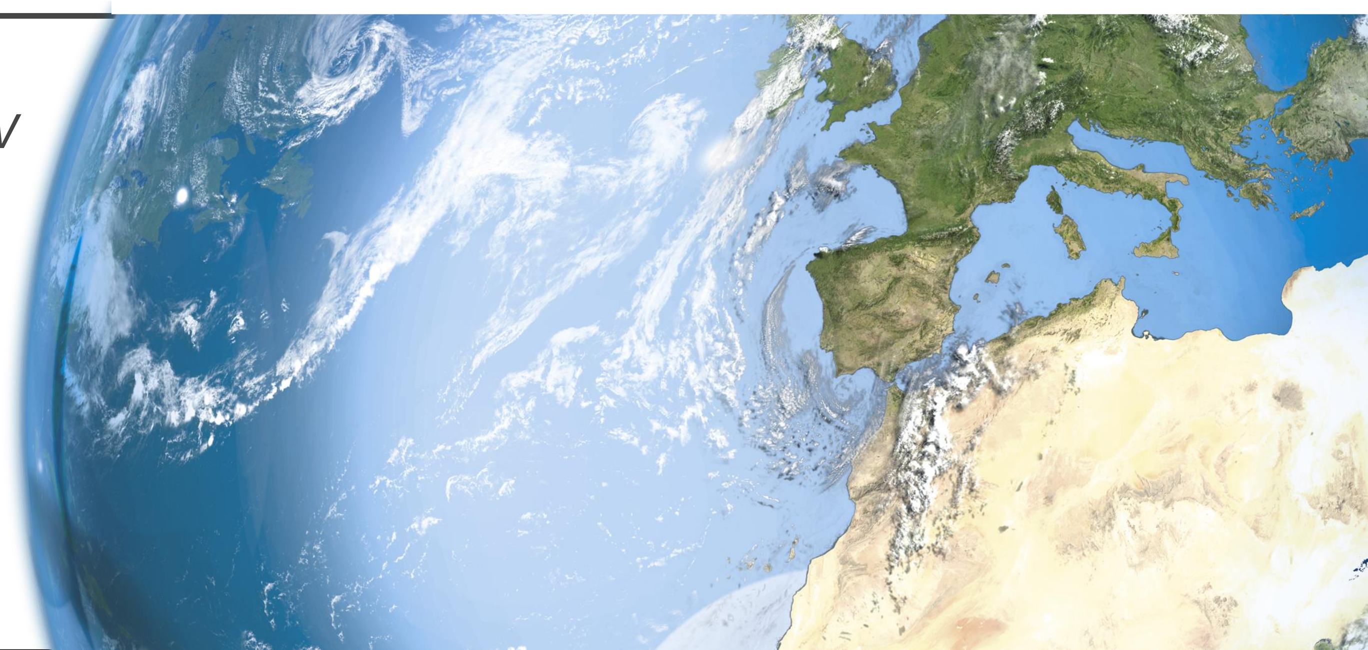

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