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Electrification and circularity - a plasma chemistry perspective

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Sustainable energy generation by means of wind or from solar radiation through photovoltaics or concentrated solar power will continue to increase its share of the energy mix. Intermittency due to e.g. day/night cycle, regional variation in availability, and penetration of sustainable energy into sectors other than electricity such as the chemical industry necessitates means of storage, transport and energy conversion on a large scale. A promising option is the synthesis of chemicals and artificial fuels using sustainable energy. A truly circular economy requires that the raw materials are the thermodynamically most stable ones such as CO_2 and N_2, and probably even CH_4. In this contribution it will be highlighted how plasma chemistry can potentially combine compatibility with e.g. intermittency and localized production to activate these molecules with maximum energy efficiency. Starting from a prevalent picture within the field of preferential vibrational excitation (causing inherently strong out-of-equilibrium processing conditions that achieve selectivity in the reaction processes) that may intensify chemical reactions, it will be shown how high power densities create fast dynamics that can be exploited in thermal routes. Examples will be discussed that connect to carbon capture and utilization, to nitrogen fixation, and to carbon circularity. These examples will be put within the context of the Brightsite initiative, a public – private collaboration within which 'Sitech Services', the 'Brightlands Chemelot Campus', TNO, and the Maastricht University join forces to (i) demonstrate that 2030-2050 climate goals 2030 and 2050 can be reached at Chemelot Industrial Site and (ii) to educate the next generation of scientists, researchers, engineers and coworkers.

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