

Steady State and Time Dependent Compressed Air Energy Storage Model Validated with Huntorf Operational Data and Investigation of Hydrogen Options for a Sustainable Energy Supply Friederike Kaiser

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wind power and photovoltaic energy play a significant role in sustainable energy systems however these two renewable energy sources do not generate electrical energy on demand and are subject to natural fluctuations thus the need for compensatory measures arises compressed air energy storage power plants caes are a possible solution to providing negative and positive control energy in the electric grid however in contrast to other energy storage devices such as pumped hydro energy storage or batteries the storage medium compressed air hardly contains any energy or more precisely enthalpy yet compressed air storage allows the operation of highly efficient gas turbines which are not only particularly fast available but also achieve better efficiency than combined cycle power plants used today as illustrated by the example of the modern gas and steam power plant irtsching with η_{tc} 60 from 2011 compared to the 20 years older mcintosh caes with η_{tc} 82.4 in this thesis the calculation methods for the thermodynamics of the caes process are presented and validated by measured data from the operations of the caes power plant huntorf both the steady state and the dynamic time dependent analyses of the process take place the characteristic value efficiency is discussed in detail since numerous different interpretations for caes exist in the literature a new calculation method for the electric energy storage efficiency is presented and a method for the calculation of an economically equivalent electricity storage efficiency is developed consideration is given to the transformation of the caes process into a hydrogen driven and thus greenhouse gas free process finally a model caes system is tested in a 100 renewable model environment consequently it can be stated that in the steady state thermodynamic calculation in particular the consideration of realistic isentropic efficiencies of compressors and turbines is essential to correctly estimate the characteristic values of the process furthermore a steadystate view should always be accompanied by dynamic considerations since some process characteristics

are always time dependent the simulation shows that by mapping transient operating conditions the overall efficiency of the system must be corrected downwards nevertheless in the model environment of a 100 renewable energy system it has been shown that a caes is a useful addition that can provide long term energy storage

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