



System's flips in climate-related energy (CRE) systems

Maria-Helena Ramos (1), Jean-Dominique Creutin (2), Kolbjørn Engeland (3,4), Baptiste François (5), and Benjamin Renard (6)

(1) Irstea, Hydrology Research Group, Antony, France (maria-helena.ramos@irstea.fr, +33 (0) 1 40 96 61 21), (2) LTHE, Université de Grenoble 1 & 2, CNRS, G-INP, Grenoble, France, (3) University of Oslo, Oslo, Norway, (4) Norwegian Water Resources and Energy Directorate, Oslo, Norway, (5) University of Padova, Padova, Italy, (6) Irstea, UR HHLY, Lyon, France

Several modern environmental questions invite to explore the complex relationships between natural phenomena and human behaviour at a range of space and time scales. This usually involves a number of cause-effect (causal) relationships, linking actions and events. In lay terms, 'effect' can be defined as 'what happened' and 'cause', 'why something happened.' In a changing world or merely moving from one scale to another, shifts in perspective are expected, bringing some phenomena into the foreground and putting others to the background. Systems can thus flip from one set of causal structures to another in response to environmental perturbations and human innovations or behaviors, for instance, as space-time signatures are modified. The identification of these flips helps in better understanding and predicting how societies and stakeholders react to a shift in perspective. In this study, our motivation is to investigate possible consequences of the shift to a low carbon economy in terms of socio-technico systems' flips. The focus is on the regional production of Climate-Related Energy (CRE) (hydro-, wind- and solar-power). We search for information on historic shifts that may help defining the forcing conditions of abrupt changes and extreme situations. We identify and present a series of examples in which we try to distinguish the various tipping points, thresholds, breakpoints and regime shifts that are characteristic of complex systems in the CRE production domain. We expect that with these examples our comprehension of the question will be enriched, providing us the elements needed to better validate modeling attempts, to predict and manage flips of complex CRE production systems. The work presented is part of the FP7 project COMPLEX (Knowledge based climate mitigation systems for a low carbon economy; <http://www.complex.ac.uk/>).