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Interactions between land use, climate and hydropower in Scotland

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To promote the transition towards a low carbon economy, the Scottish Government has adopted ambitious energy targets, including generating all electricity from renewable sources by 2020. To achieve this, continued investment will be required across a range of sustainable technologies.

Hydropower has a long history in Scotland and the present-day operational capacity of $\sim$1.5 GW makes a substantial contribution to the national energy budget. In addition, there remains potential for $\sim$500 MW of further development, mostly in the form of small to medium size run-of-river schemes.

Climate change is expected to lead to an intensification of the global hydrological cycle, leading to changes in both the magnitude and seasonality of river flows. There may also be indirect effects, such as changing land use, enhanced evapotranspiration rates and an increased demand for irrigation, all of which could affect the water available for energy generation.

Preliminary assessments of hydropower commonly use flow duration curves (FDCs) to estimate the power generation potential at proposed new sites. In this study, we use spatially distributed modelling to generate daily and monthly FDCs on a 1 km by 1 km grid across Scotland, using a variety of future land use and climate change scenarios. Parameter-related uncertainty in the model has been constrained using Bayesian Markov Chain Monte Carlo (MCMC) techniques to derive posterior probability distributions for key model parameters.

Our results give an indication of the sensitivity and vulnerability of Scotland's run-of-river hydropower resources to possible changes in climate and land use. The effects are spatially variable and the range of uncertainty is sometimes large, but consistent patterns do emerge. For example, many locations are predicted to experience enhanced seasonality, with significantly lower power generation potential in the summer months and greater potential during the autumn and winter. Some sites may require infrastructural changes in order to continue operating at optimum efficiency.

We discuss the implications and limitations of our results, and highlight design and adaptation options for maximising the resilience of hydropower installations under changing future flow patterns.