Space Weather, Electricity Flows, and the Smart Grid

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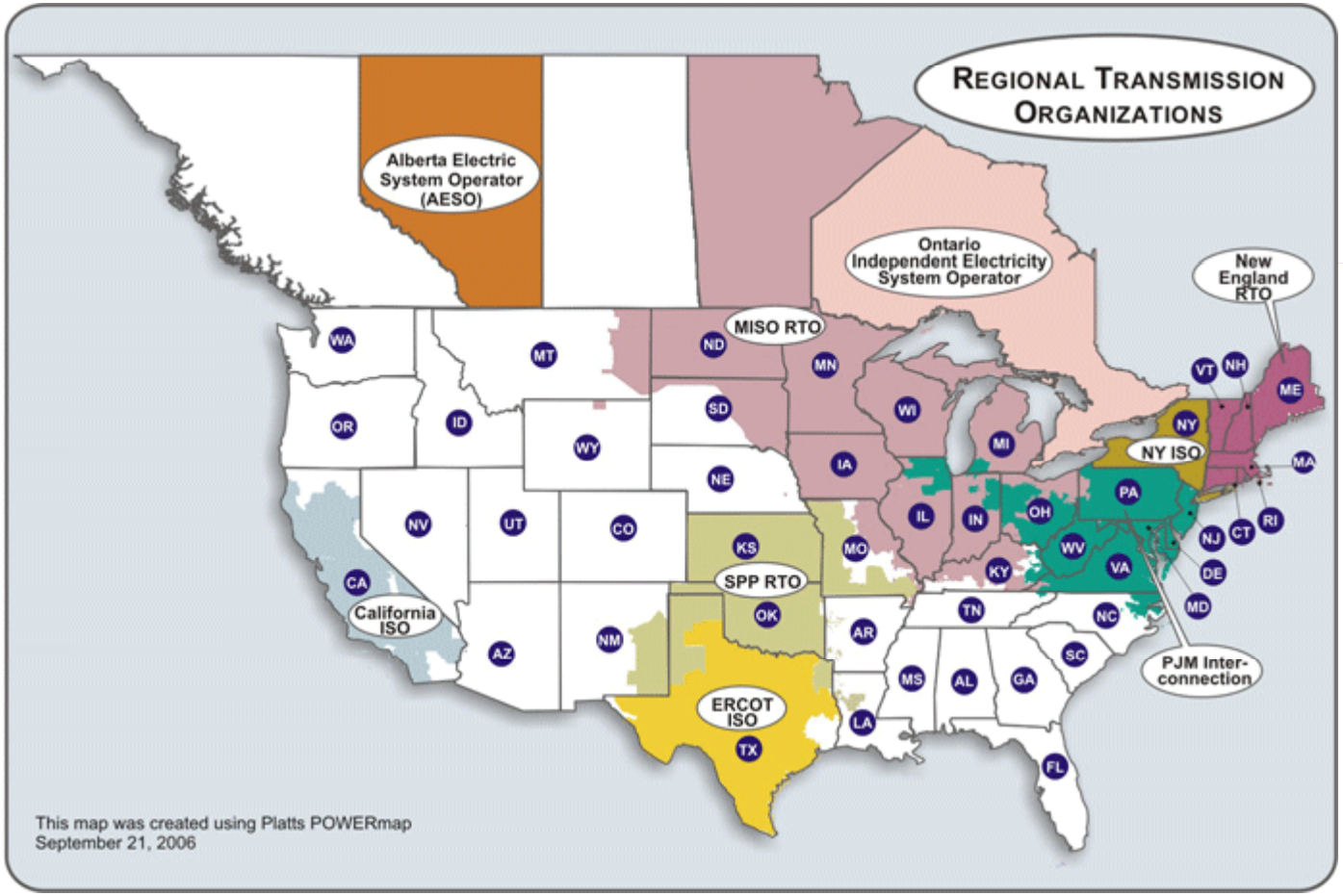
Introduction

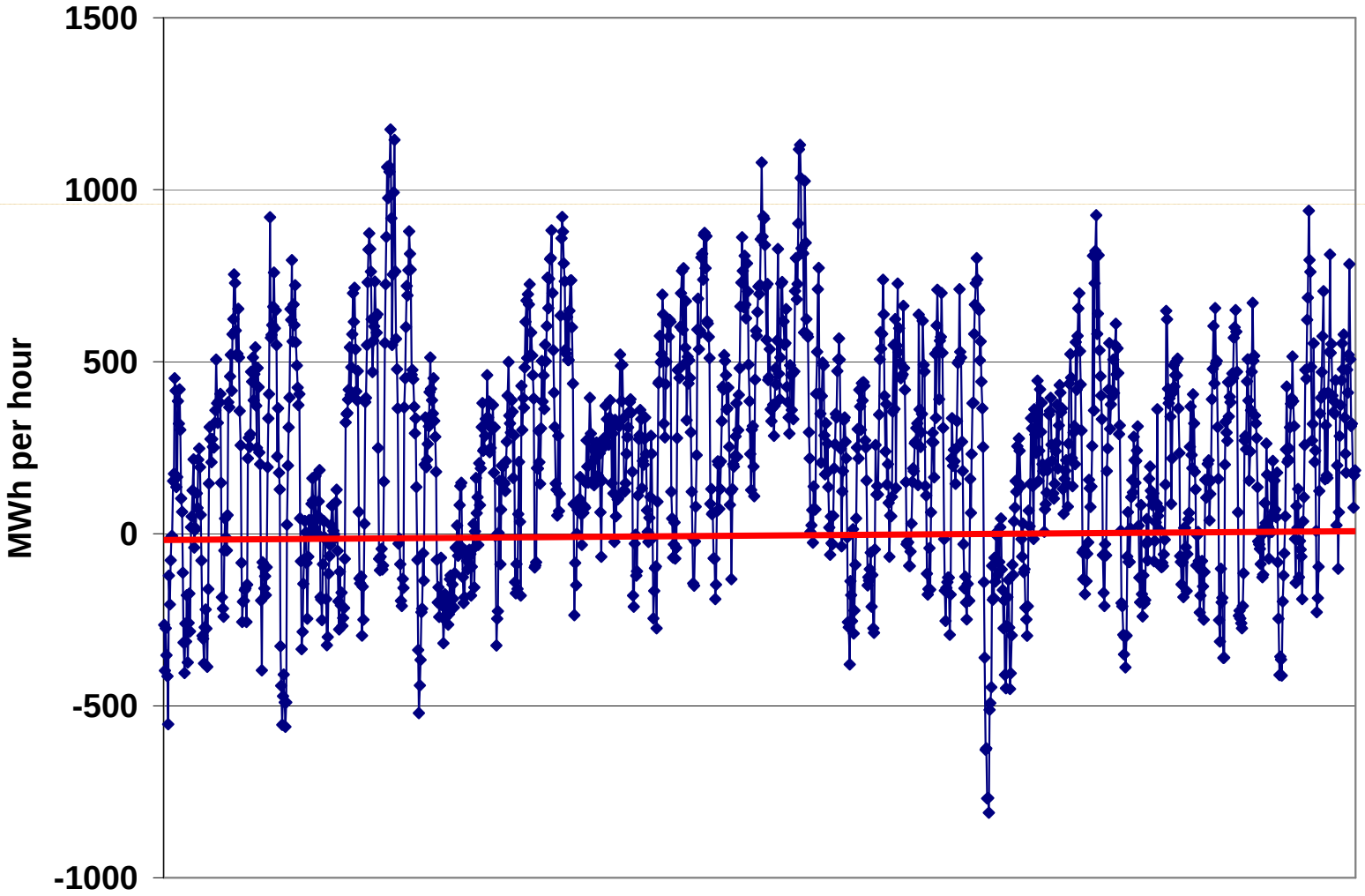
- **In a well functioning market, the quantity of a commodity that is delivered to a buyer will not be systemically different from the amount that was scheduled to be delivered.**
- **Attainment of this property is especially important in electricity where the stability of a power grid requires that generation plus net electricity flows from other power grids be almost exactly equal to consumption at all times.**

- **On alternating current transmission systems, actual and scheduled electricity flows between two control areas are seldom equal.**
- **These differences are known as "Loop Flows." Also known as unscheduled flows and inadvertent flows.**
- **In terms of loop flows, system operators are "flying blind" and thus the goal of the grid being "Smart" is very far from being realized.**

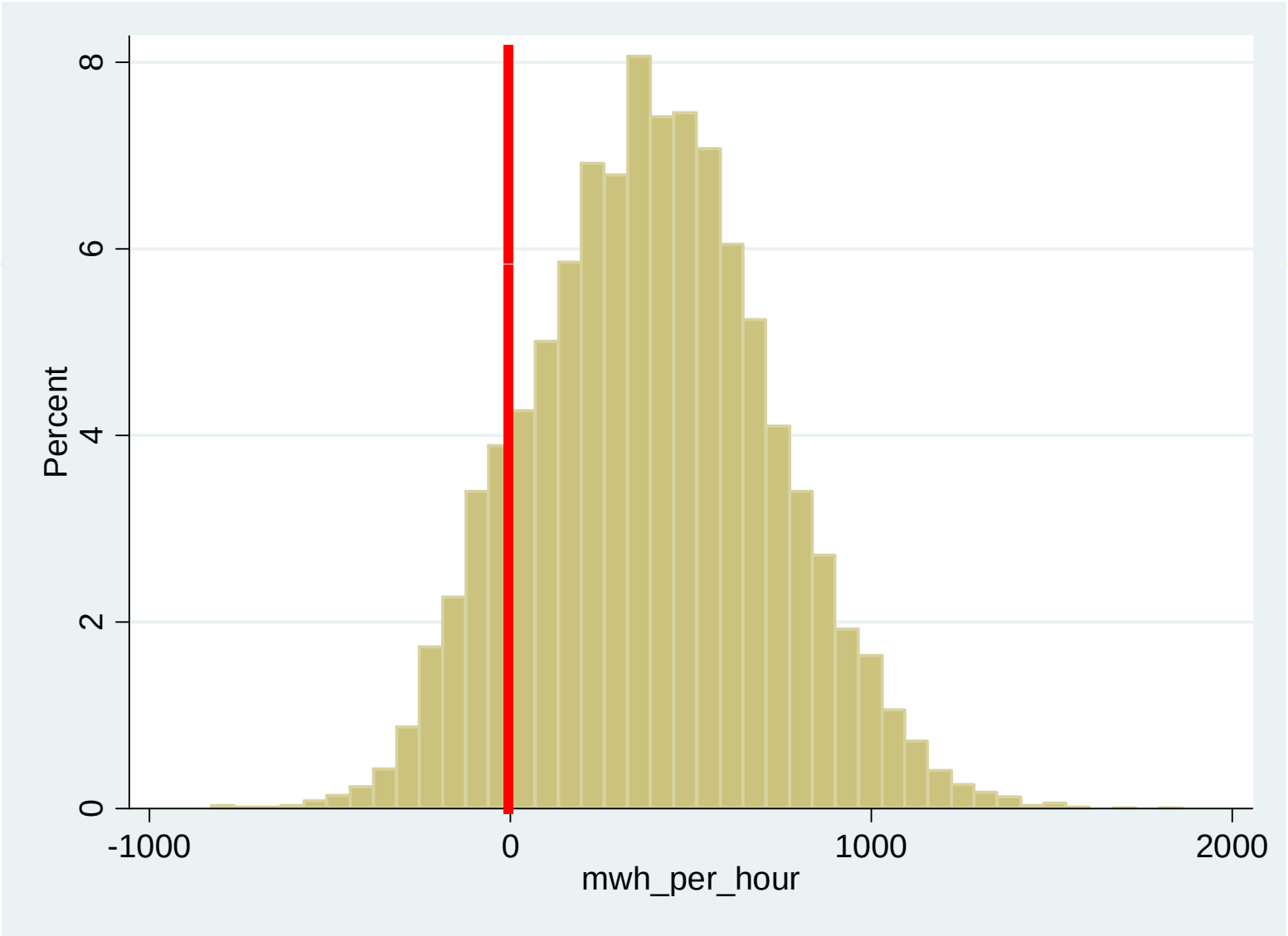
Regional Transmission Organizations in North America



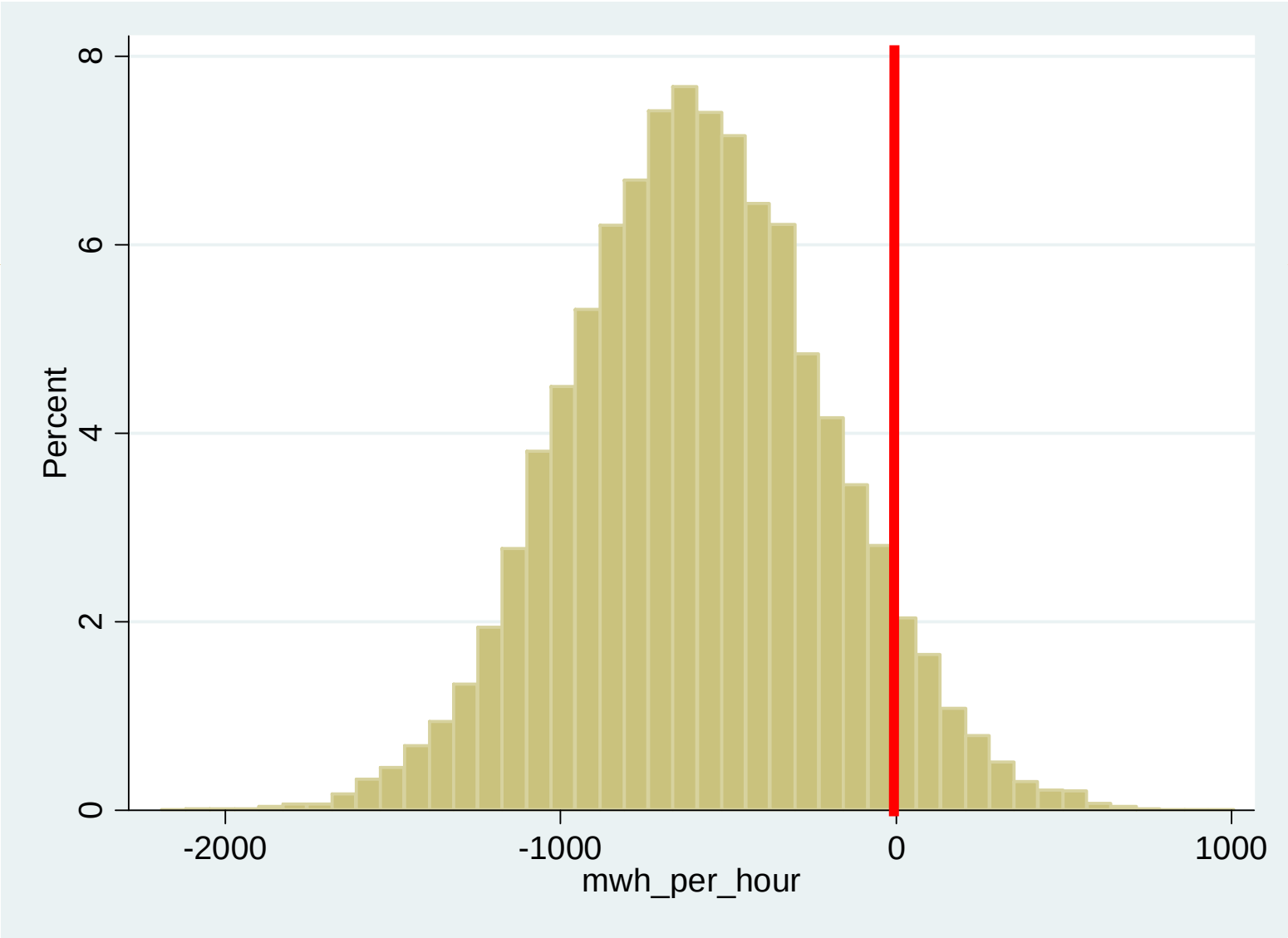
PJM's Loop Flows with New York, 1 June – 31 July 2002.



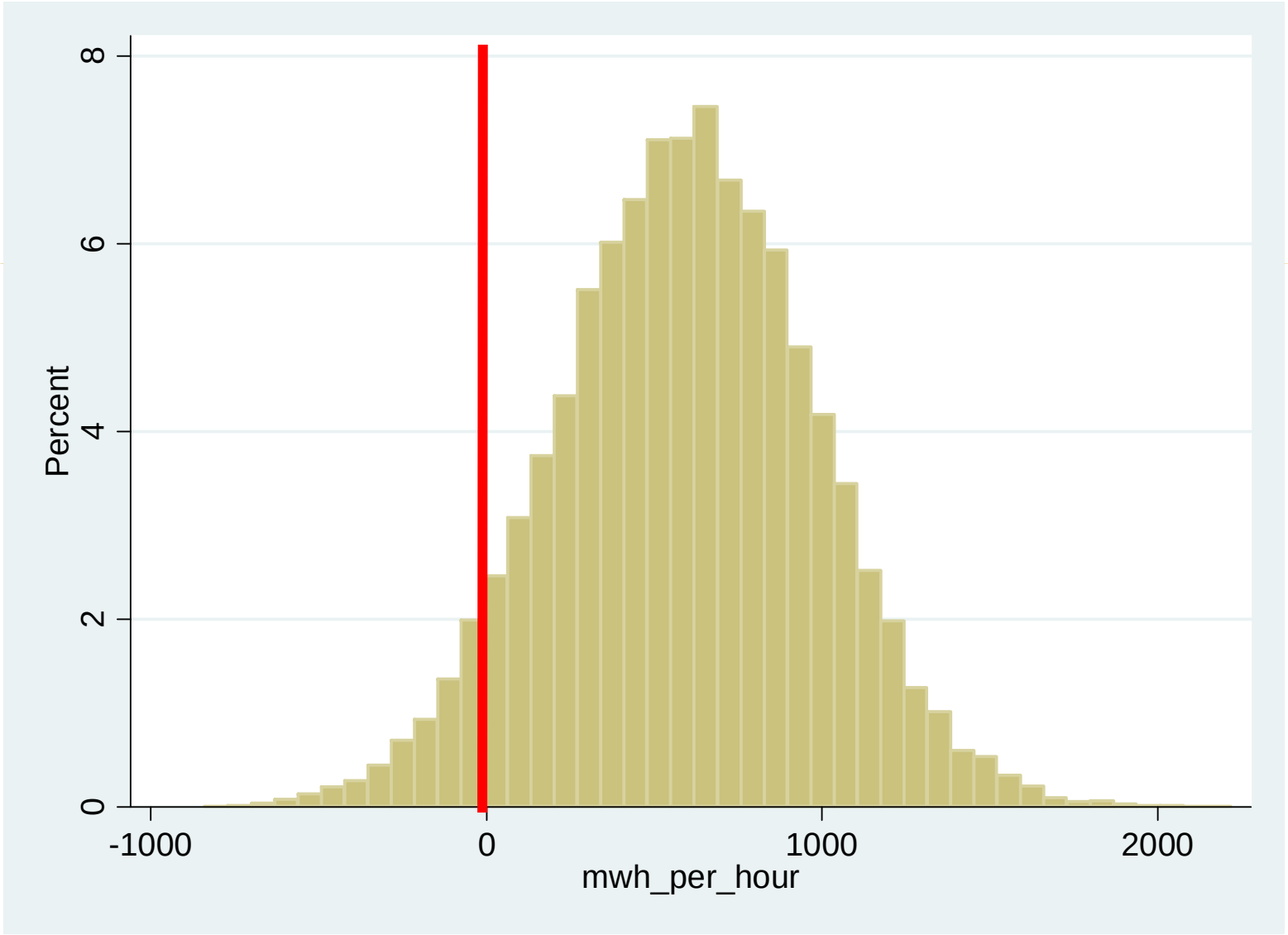
A Histogram of PJM's Loop Flows with New York, 1 April 2002 – 30 April 2004



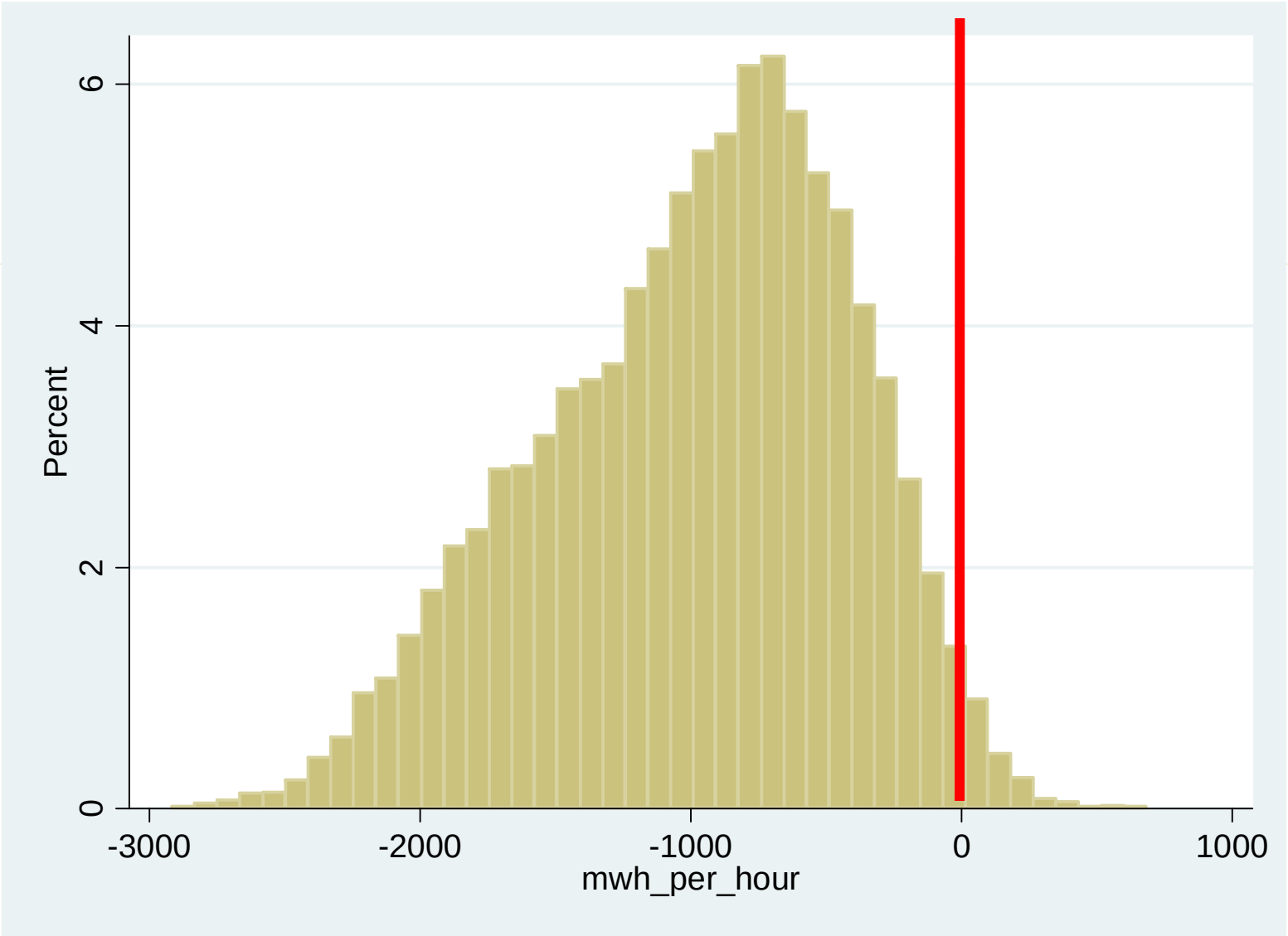
A Histogram of Ontario's Loop Flows with Michigan, 1 Jan 2004 – 31 December 2006



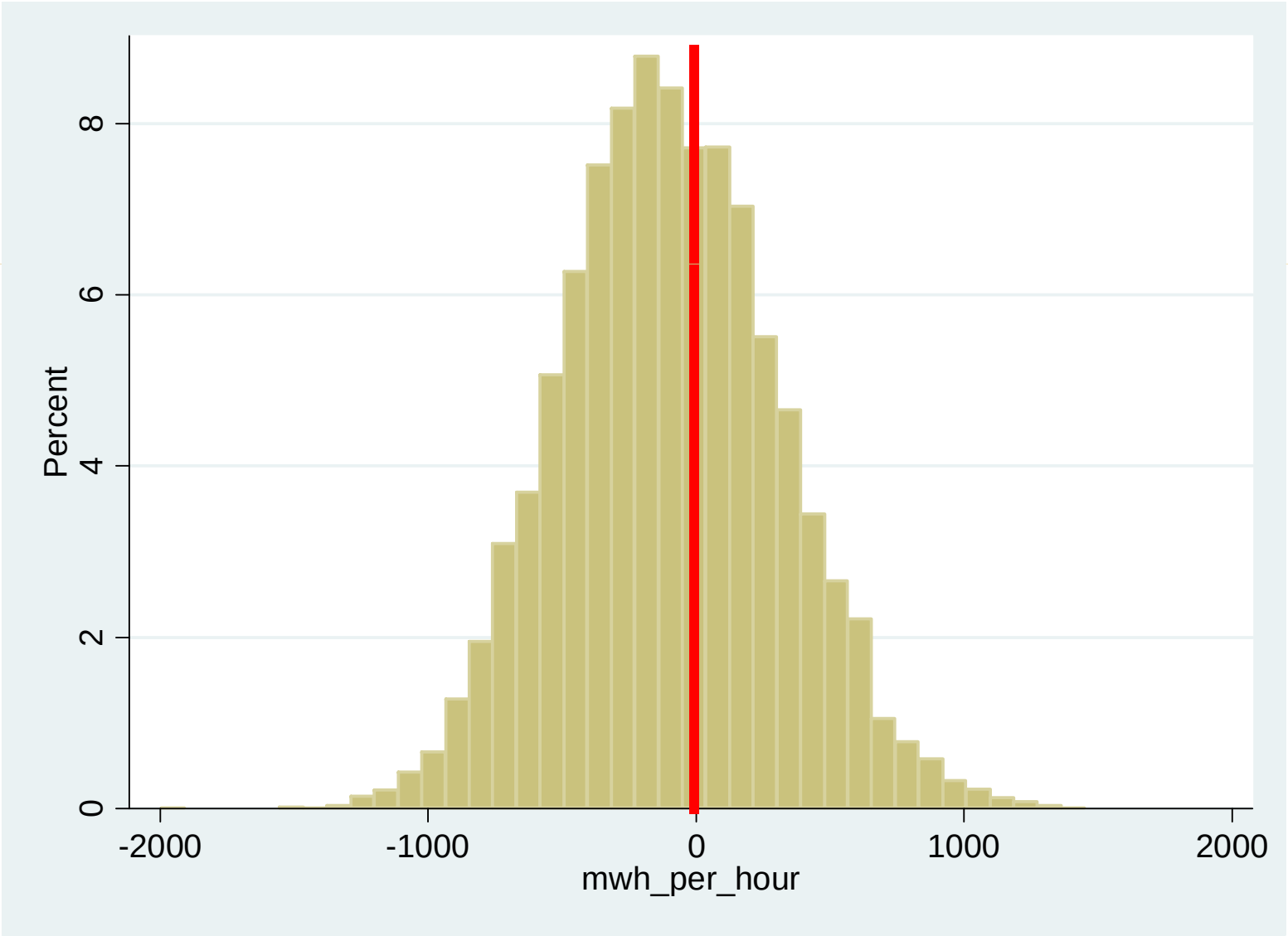
A Histogram of Ontario's Loop Flows with New York, 1 Jan 2004 – 31 December 2006



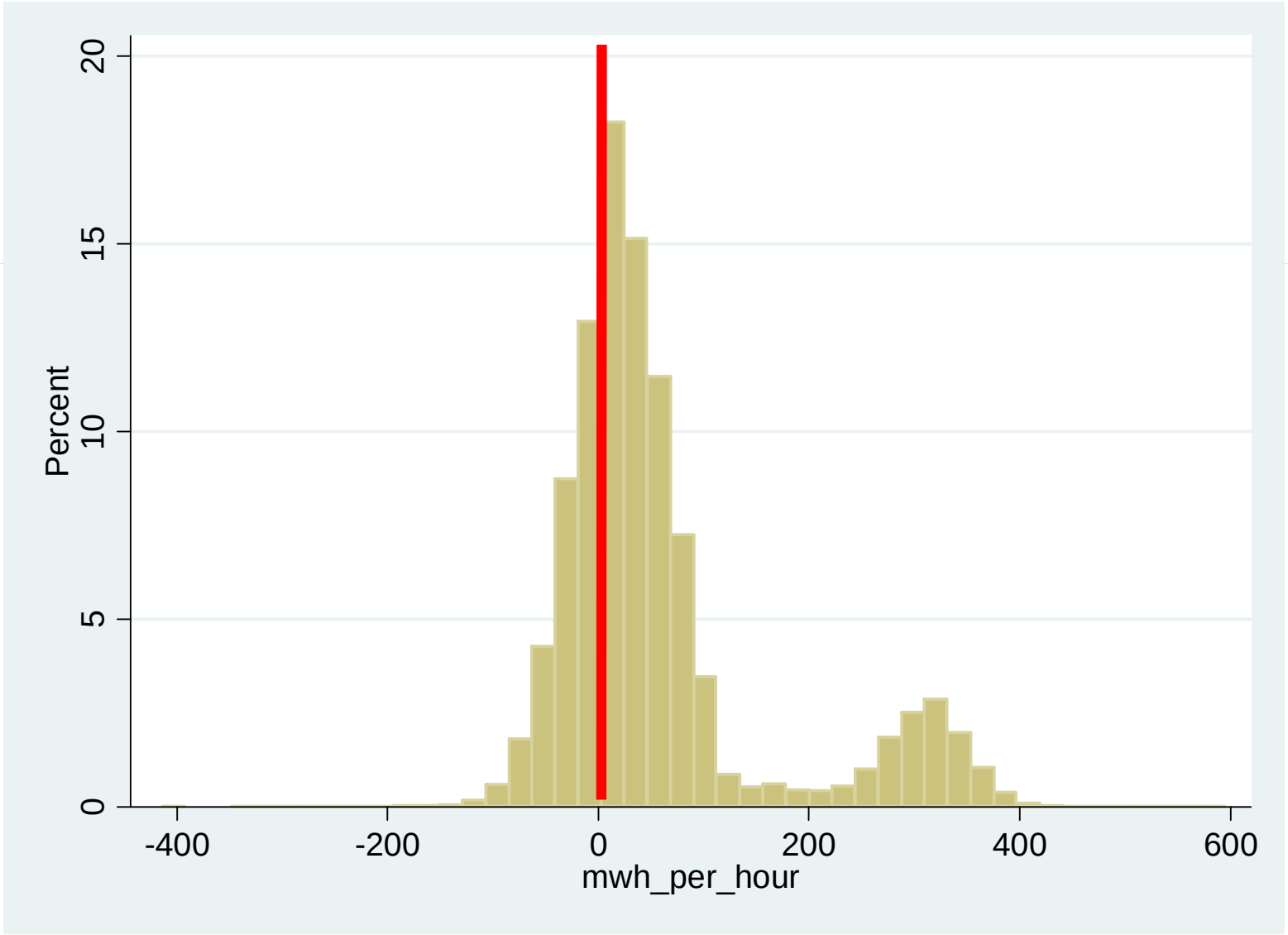
A Histogram of PJM's Loop Flows with the Tennessee Valley Authority, 1 July 2005 – 31 December 2007



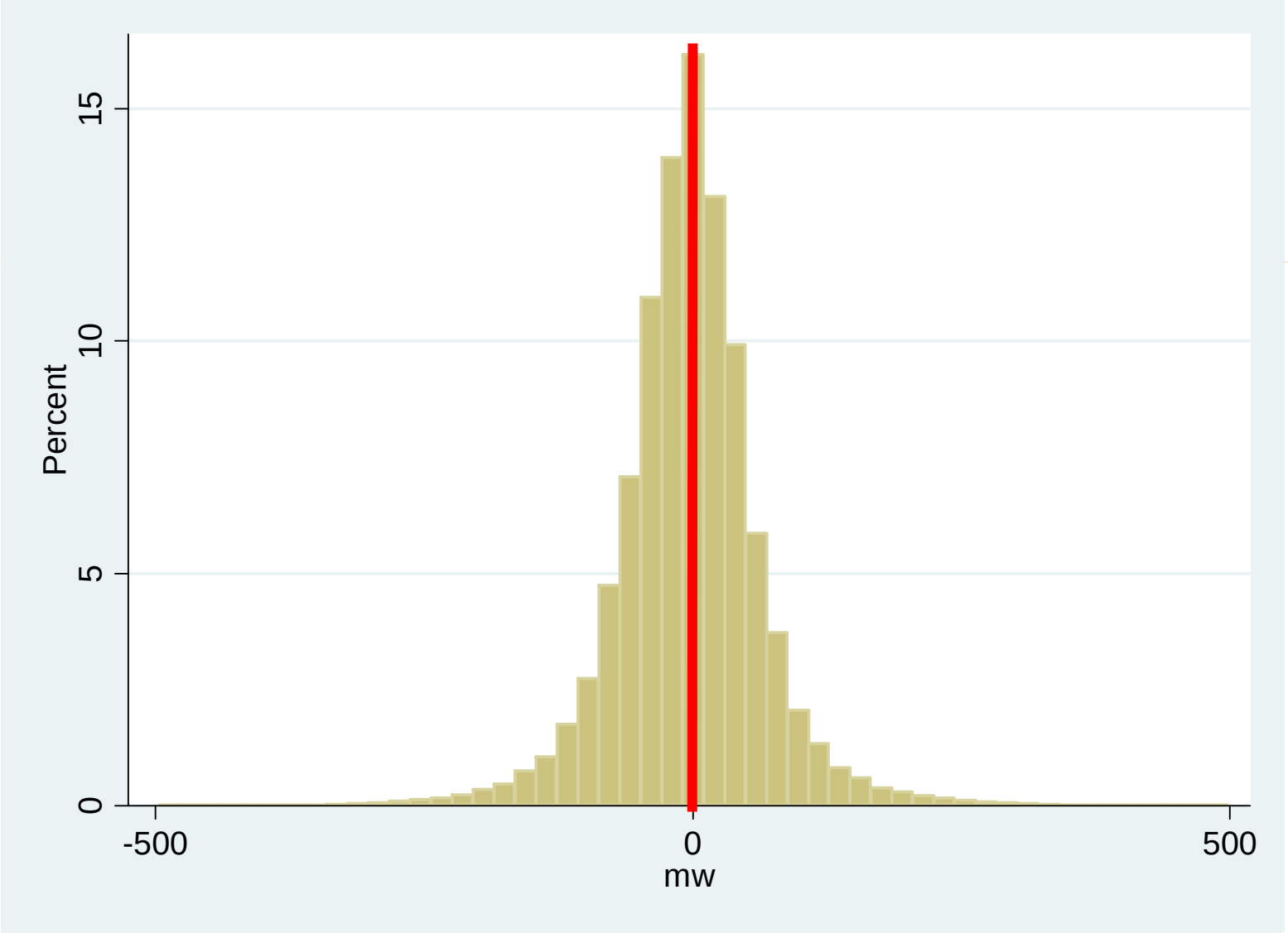
A Histogram of the Loop Flows at the Malin Intertie in Northern California, 1 December 2006 – 30 November 2007



A Histogram of Loop Flows between Western Denmark and Germany,1January 2001 – 31 December 2005



A Histogram of Net Loop Flows between Netherlands and Its Trading Partners,1January 2002 – 31 December 2005



Results and Conclusions

- **In each of the cases presented, a preliminary multivariate econometric analysis has indicated that loop flows are statistically related with a proxy for geomagnetically induced currents.**

- **In several of the cases, the model is able to "explain" the vast proportion of the variation in the loop flows.**

- **It should not be insurmountable to forecast loop flows based on space weather forecasts, forecasts of terrestrial weather, and the scheduled electricity flows.**
- **This could help make the goal of the "Smart Grid" a true reality.**