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Optimizing Natural Gas Networks through Dynamic Manifold Theory and a Decentralized Algorithm: Belgium Case Study CALEB KOCH, LEIGH WINFREY, Virginia Tech — Natural Gas is a major energy source in Europe, yet political instabilities have the potential to disrupt access and supply. Energy resilience is an increasingly essential construct and begins with transmission network design. This study proposes a new way of thinking about modelling natural gas flow. Rather than relying on classical economic models, this problem is cast into a time-dependent Hamiltonian dynamics discussion. Traditional Natural Gas constraints, including inelastic demand and maximum/minimum pipe flows, are portrayed as energy functions and built into the dynamics of each pipe flow. Doing so allows the constraints to be built into the dynamics of each pipeline. As time progresses in the model, natural gas flow rates find the minimum energy, thus the optimal gas flow rates. The most important result of this study is using dynamical principles to ensure the output of natural gas at demand nodes remains constant, which is important for country to country natural gas transmission. Another important step in this study is building the dynamics of each flow in a decentralized algorithm format. Decentralized regulation has solved congestion problems for internet data flow, traffic flow, epidemiology, and as demonstrated in this study can solve the problem of Natural Gas congestion. A mathematical description is provided for how decentralized regulation leads to globally optimized network flow. Furthermore, the dynamical principles and decentralized algorithm are applied to a case study of the Fluxys Belgium Natural Gas Network.

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