The increasing share of volatile and inverter-based energy sources render electric power grids increasingly susceptible to disturbances. Established Load Frequency Control (LFC) schemes are rigid and require careful tuning, making them unsuitable for dynamically changing environments. In this paper, we present a fast and tuningless frequency control approach that tackles these shortcomings by means of modern grid monitoring and communications infrastructures in a two-fold concurrent process. First, direct observation of supply and demand enables fast power balancing decoupled from the total system dynamics. Second, primary resources are actively involved in frequency restoration by systematic adjustment of their frequency reference setpoints. In contrast to the commonly used Automatic Generation Control (AGC), the proposed Direct Load Frequency Control (DLFC) does not require an integrator for frequency control in the closed loop even under partial grid observability. The approach is Lyapunov-stable for a wide range of system parameters, including ramping limits of controlled resources. A performance study against AGC has been conducted on a three-area power system in simulations as well as in a real laboratory grid with an installed generation capacity of 110 kW.