

### 12.3 **Past, Present, and Pending Intellectual Property for Heating Oil Shale with Electromagnetic Energy**

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Electromagnetic heating of oil shale formations has a long history of intellectual property protection. An early patent from 1953 is among the first to describe use of electrothermal energy to extract oil (patent 2,634,962, by F Ljungstrom). Since then, there have been many patents granted for various apparatuses and methods of pyrolyzing kerogen with electromagnetic energy for conversion and capture of shale oil. The apparatuses and methods described over the years range from volumetric heating, to rapid heating, to rotating electromagnetic fields, to inclusion of critical fluids, to robust heating controls. This presentation provides a cursory overview of expired patents, in force patents, and patents pending for electromagnetic heating of oil shale. Although a detailed explanation of each technology as well as conclusions about capabilities of each patented technology are beyond the scope of this presentation, the vast amount of intellectual property over time shows a technology trend of improved performance attributes. An overview of the activities of Quasar Energy LLC on its patents for robust heating controls for Radio Frequency heating of oil shale will also be presented:

7,091,460 for Automatic Impedance Matching RF Heating

7,109,457 for Variable Frequency RF Heating

7,115,847 for Impedance vs. Temperature RF Heating

7,312,428 for Resonance Frequency vs. Temperature RF Heating