Recent developments of high-end processors recognize energy monitoring and tuning as one of the main challenges towards achieving higher performance given the growing power and temperature constraints. Our thermal energy model is based on application-specific parameters such as consumed power, execution time, and equilibrium temperature as well as hardware-specific parameters such as half time for thermal rise or fall. As observed with the out-of-band instrumentation and monitoring infrastructure on our experimental cluster with air cooling, the temperature changes follow a relatively slow capacitor-style charge-discharge process. Therefore, we use the lumped thermal model that initiates an exponential process whenever there is a change in processor’s power consumption. Experiments with two codes – Firestarter and Nekbone – validate our approach and demonstrate its use for analyzing and potentially improving the application-specific balance between temperature, power, and performance.