Applications

Tenkiv's solar power technology is designed to be able to provide energy for any application. In most places on earth it will be able to produce 100% of the energy for that region at substantially lower costs than fossil fuels. Tenkiv solar collectors produce heat directly. One advantage of starting with heat is that the quality of the energy produced is completely variable. This is important because lower quality energy (e.g. low temperature heat) can produced much more efficiently than high quality energy (e.g. electricity) and so the losses involved in producing higher quality energy should only be taken when absolutely necessary.

While the Tenkiv solar collectors produce heat directly, the system makes use of various modules to process that heat which is what allows it do things besides direct heating. There are many potential applications of these thermal processes that may be useful for more efficiently addressing specific use cases (e.g. using a heat engine to directly move a conveyer belt in a factory rather than converting to electricity then using an electric motor.) and in the future it may make sense to develop highly optimized application specific processes for some of these. However, in practical terms, the vast majority of use cases can be addressed fairly optimally through three processes:

1. **Direct heating**. Direct, low temperature heating currently accounts for about 1/3 of the world's energy consumption. As mentioned earlier, this application can be addressed at extremely high efficiencies, so it is worth optimizing production for this use.
    a. Heat flow:
        i. Space heating: Heat is transferred from inside the solar collector to a heat exchanger by saturated vapor phase change. Vapor condenses in the heat exchanger, heat is transferred to hydronic radiator or radiant floor or ceiling, vapor to gas heat exchanger for forced or natural convection air heating.
        ii. Hot water heating: Heat is transferred by phase change inside the solar collector, as in [i] above. Vapor condenses either in a vapor-to-liquid heat exchanger located centrally in the building or facility, which heats the hot water, then the hot water flows to point of use , or to a heat exchanger at the point of use, where water is heated as it is used.
        iii. For other direct heating uses the heat is moved from the collector to the use by phase change, then the vapor is condensed as heat is removed to heat the end use.

        iv. The condensed vapor then returns to the collector, either by gravity flow, if the end use is located above the collector, or through the use of a pump if the end use is below the collector.
    b. Examples:
        i. Water purification (distillation and pasteurization).
        ii. Home and commercial building space heating.
        iii. Water heating.
        iv. Food processing (cooking and sanitizing).
        v. Industrial chemical processing.
        vi. Heat treatment in manufacturing.
2. **Heat pumping** (i.e. using heat to move heat). This is what air conditioners do, only powered directly by thermal energy rather than electricity. This process is most applicable for cooling. While energy consumption for cooling applications isn't as high as it is for heating, it is still substantial and the equipment for powering cooling thermally is the same cost as powering it from electricity, so the end to end efficiency gain from powering it thermally comes at no extra cost. This same process can be used for heating processes to provide a performance factor greater than unity (apparent efficiency greater than 100%)
    a. Heat flow:
        i. Heat is transferred directly to the heat transfer fluid inside the collector by phase change, then to the heat pump, or to a heat exchanger which then moves the heat to the working fluid of the heat pump, then is used by the heat pump to pump heat. Phase change heat transfer fluid is then returned to the collector by gravity of through pumping.
    b. Process examples:
        i. Absorption refrigerator
        ii. Absorption heat pump
    c. Use examples:
        i. Home and commercial building space cooling and heating
        ii. Refrigeration.
3. **Electricity generation.** Today most electricity is already produced by converting to it from heat. Fossil fuels are burned, converting its chemical potential energy to heat, that heat then powers some kind of heat engine which ultimately produces electricity. In the Tenkiv system the collectors produce higher temperature heat when needed for electricity production. The heat is then put through a heat engine to produce electricity. The net efficiency of producing electricity with the Tenkiv system is similar to the efficiency of producing electricity with photovoltaic solar collectors (but at much lower costs).
    a. Heat flow:
        i. Heat is transferred directly to phase change heat transfer fluid in the collector. The phase change vapor is condensed directly in the "heat

engine" (listed in process examples in part b.) or is transferred to the heat process (heat engine) by condensing heat transfer fluid in a heat exchanger as heat is removed to power the process examples.

b. Process examples:
    i. Rankine cycle steam engine
    ii. Regenerative cycle steam engine
    iii. Organic Rankine cycle
    iv. Ericsson cycle
    v. Stirling cycle
    vi. Johnson thermoelectric energy converter
    vii. Peltier-Seedbeck effect thermoelectric generator
    viii. Thermogalvanic cell
    ix. Thermoionic emission
    x. Thermotunnel cooling
    xi. Thermo-magnetic motor
c. Use Examples:
    i. Charging an EV.
    ii. Powering a computer.
    iii. Lighting.
    iv. Welding.
    v. Any process that uses electricity or mechanical energy.

Energy Storage

Tenkiv's solar power technology is designed to be able to easily store the collected energy for later use through various methods:

1. Thermal battery: using a thermal battery, the Tenkiv system can directly store the heat produced by the collectors. This can be done by either:
    a. Heating any substance and storing energy by the increased temperature of the substance.
    b. Changing the state of a substance and storing energy by the change from a lower energy state to a higher energy state.
    c. A combination where direct heating is used for one circuit in a Tenkiv system and state change is used for another. In this case the hotter thermal battery may be placed inside the cooler one to reduce loss.
2. Fly wheel
3. Spring
4. Compressed fluid
5. Elevated mass
6. Electrochemical battery
7. Capacitor

8. Supercapacitor
9. Superconducting magnetic energy storage
10. Hydrated salts
11. Production of certain chemicals for energy storage

Control & Automation

Tenkiv's solar power technology is designed to be managed by a device which is capable of processing and interpreting input data from various sources (via custom software) in order to optimize the efficiency of the system. Data input sources include, but are not limited to:

1. Using sensor data from Tenkiv's solar power system to:
    a. manage which circuit (hot/warm) the collectors should be connected to
    b. designate where heat should flow throughout a system, whether to an application that might need it, to be converted into another form of energy, or stored for later use
    c. diagnose any potential low-absorption areas such as part of a collector that may have gotten blocked from receiving light
        i. this sensor data can also be used to trigger a mechanism that will remove any blocking materials from the surface of the collector if detected
    d. detect the optimal angle the collectors should move / rotate to in order to ensure maximum thermal energy collection
    e. detect and seal any areas that might be experiencing a leak in vacuum pressure
2. Using weather data to:
    a. predict how much energy will be produced in the near future and use that data to inform system configuration changes
    b. predict how much energy will be produced on average over longer timespans and use that data to inform system configuration changes
    c. calculate how much energy has been produced historically in a particular region and use that data to inform system configuration changes
    d. predict optimal use of stored energy
    e. predict any upcoming moments of fluctuating or inconsistent energy production that would require the system to take energy from storage or secondary energy source
    f. calculate how much excess energy will be produced over a given timespan that might be sold to utilities or transferred into other connected systems
3. Using user data to:
    a. predict and recognize common user usage patterns in order to move heat more efficiently throughout the system for the desired end use

   b. detect areas that do not need energy at a given time based on a lack of user presence (automatic motion detection or manual indication) or preference, and turn off / pause any systems that may be being powered in those areas
   c. detect areas that require energy at a given time based on user presence (automatic motion detection or manual indication) or preference, and turn on / resume any systems that may be being powered in those areas
   d. inform the user of energy usage habits and patterns
4. Using <u>market data</u> to:
   a. Obtain an accurate reading of current market values of energy kw/h and predict income from selling energy produced by the Tenkiv system

The Tenkiv system's automation system relies on a central device or multiple devices to manage the various data input sources and output a corresponding command to send to the system. These commands can be issued locally (via the local server hosted on the device connected to the sensors) or remotely via an external connection (e.g. internet, bluetooth). These devices can also manage any configuration of multiple systems and/or modules to distribute energy between them.