Sankey Diagrams Help Army Installations Target Opportunities to Enhance Energy and Water Efficiency

By Hon. Alex Beehler, Assistant Secretary of the Army (Installations, Energy and Environment) and Mr. J.E. "Jack" Surash, P.E., Acting Deputy Assistant Secretary of the Army for Energy and Sustainability, January 2021

Secure and reliable access to energy and water on Army installations is essential to mission readiness and for the Total Army to deploy, fight, and win in a complex world. As we progress toward the Army of 2028, we are focusing on increasing our installation energy and water resilience, efficiency, and affordability. To accomplish this, the Army must maintain a clear picture of how installation energy and water support critical mission installation capabilities and requirements.

Identifying ways to quantify and articulate the value of energy and water efficiency and conservation has always been a challenge. The Assistant Secretary of the Army (Installations, Energy and Environment) (ASA (IEE)) turned to Sankey models used by Department of Energy's (DOE) Lawrence Livermore National Laboratory (LLNL) to further define the inter-relationships involved in managing installation energy and water. Since the 1970s, LLNL has developed Sankey diagrams that capture the United States energy and water usage to outline productive uses and losses. These diagrams highlight the impact energy and water efficiency and conservation measures can have across various sectors.

What the Army Installation Energy and Water Sankey Diagrams Reveal

Sankey Diagrams, like those below, are a type of flow diagram that provide a single-page reference about a resource and byproduct flow. The Army incorporated installation information to the diagrams to identify energy inputs, useful output, and wasted output. In 2019, the Army consumed 93.9 billion British Thermal Units (BTUs) of energy and 30.5 billion gallons of water. At the highest level, the Army Installation Energy and Water Sankey diagrams illustrate that Army installations are utilizing only 50 percent of energy and 40 percent of water in a productive manner. Sankey Diagrams highlight the impact energy and water efficiency and conservation measures can have to support resilience and reduce overall utility costs for the Army.

Army Installation Energy Consumption

To develop the Installation Energy Sankey diagram (Figure 1 below), the Army used the annual installation energy consumption data collected at our four land holding commands: Army Materiel Command (AMC), Installation Management Command (IMCOM), Army National Guard (ARNG), and U.S. Army Reserves (USAR), represented by the gray boxes in center-right of the chart.

Starting from the left side of the chart, you see representation of the various energy generation sources powering Army installations. These sources range (top to bottom) from solar in YELLOW at the top, down to petroleum in GREEN at the bottom. Energy sources include reported energy generation by the Army as well as the national mix on the U.S. grid that makes up the electricity the Army buys. The Army used DOE's LNNL's assumptions and calculations for rejected energy when creating this Sankey: find out more here: https://flowcharts.llnl.gov/.

Moving to the right from energy generation sources, the line paths show that some of the energy sources feed larger utility grids where our installations purchase energy as electricity (ORANGE) or steam (LIGHT BLUE), and some provide energy directly to our installations (GREYs).

As we work our way to the right of the chart, we estimate about half of this energy is used for ENERGY SERVICES (LIGHT GRAY at the bottom right) but the other half is REJECTED ENERGY (DARK GRAY at the top right). While the Army cannot do much to directly affect lost energy from central power plants and transmission and distribution losses on the grid, it can reduce lost energy once that energy arrives on the installation through conservation and efficiency practices that would affect the amount of energy put to productive use at the installation.

Each Army Installation can use the Energy Sankey to review overall energy sources by type, compare those energy source levels to policy goals, and then set efficiency goals accordingly. For example, we could compare existing energy use for services versus energy lost with Department of Defense policy goals, DOE and Federal Energy Management Program guidance, or comparable industry levels. These comparisons would inform goals to increase energy efficiency at the Army installation level.

Estimated U.S Army Installation Energy Consumption in Fiscal Year 2019: 93,913 MBtus

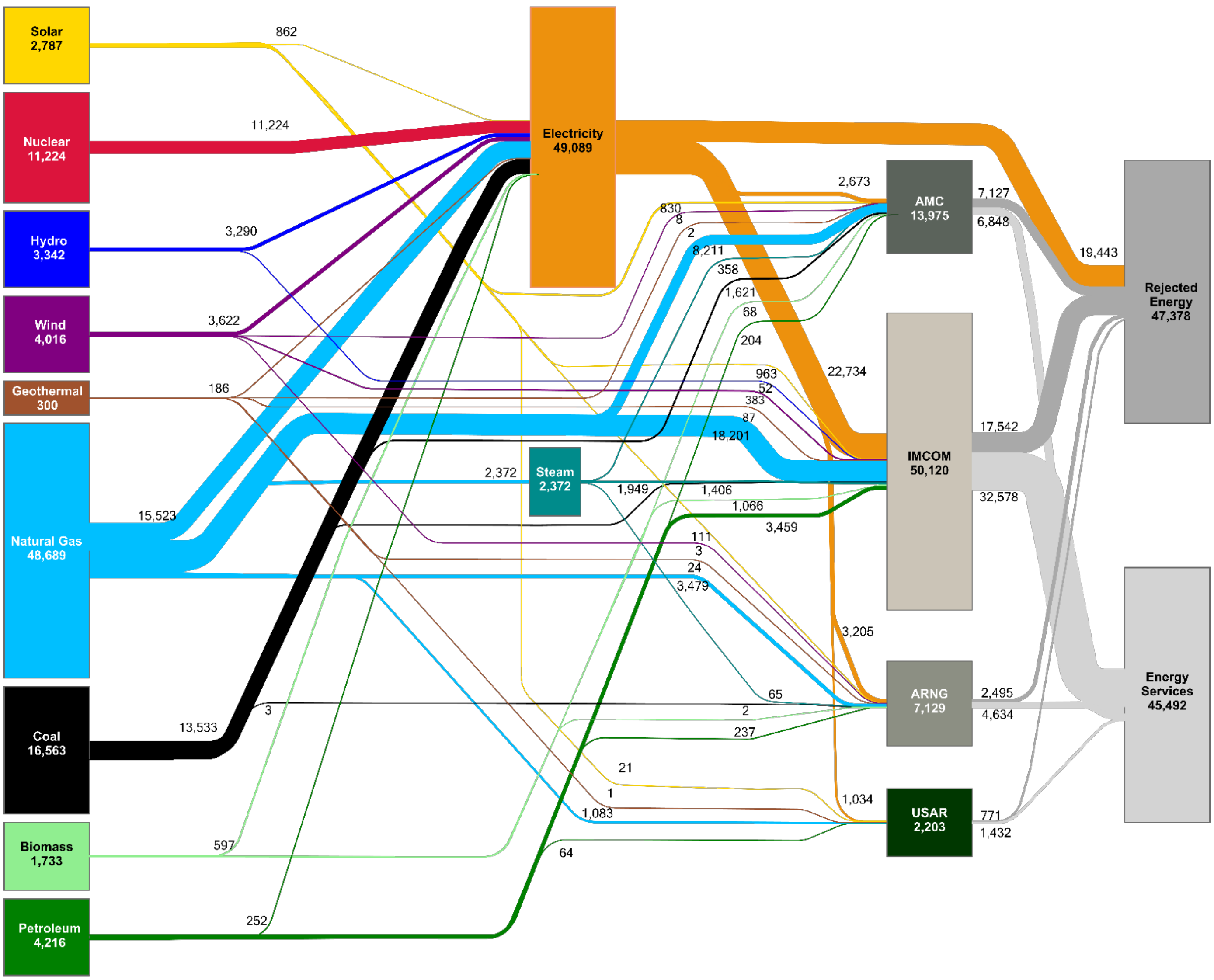

Figure 1: Army Installation Energy Sankey Diagram

In accordance with Energy Policy Act (EPAct) 2005, Army installation energy is the energy consumed in Federal buildings used by the Department of the Army at installations in the CONUS, enduring locations OCONUS, and sites managed by the Army National Guard (ARNG) and U.S. Army Reserves (USAR). The data used to create this diagram is from the FY19 Army Annual Energy Management and Resilience Report (AEMRR), DoD Army Supplemental Workbook, and the Federal Energy Management Program (FEMP) Workbook. Additional data used for estimating energy source and rejected energy is based on work completed in March 2020 by the Department of Energy and Lawrence Livermore National Laboratory (LLNL), available: https://flowcharts.llnl.gov. For the purposes of this diagram, the energy services / rejection estimates for the national industrial sector average were applied to Army Materiel Command. For Installation Management Command, the Army National Guard, and the Army Reserve, the national average for the commercial sector was used.

Army Installation Water Consumption

As with the Energy Sankey, the Army Installation Water Sankey diagram (Figure 2 below) reads from left to right, starting with representation of surface and ground water sources. The path lines illustrate the vast majority of source water is consumed as POTABLE WATER (BLUE), with comparatively tiny amounts feeding INDUSTRIAL, LANDSCAPING, and AGRICULTURE (GREEN), and ALTERNATIVE WATER (BRIGHT GREEN).

While IMCOM installations, which are also the largest of the Army's installations, consume the majority of all water, the four commands are consistent in their ratios of water lost to DISHCHARGE TO SURFACE WATER and CONSUMED or EVAPORATED.

The Water Sankey diagram enables the Army to review the usages of water overall and by type, such as potable and landscaping, and compare that to current policy goals. The Army can use this comparison to set data-driven goals and realistic timeframes in which to meet them. Energy managers and others could then focus their attention on specific projects that offer the highest potential toward meeting those goals. The same could be accomplished using wastewater discharge and consumption quantities to set goals to reduce water use, wastewater, and consumption as well as other goals.

Estimated U.S Army Installation Water Consumption in Fiscal Year 2019: 35,388 Million Gallons / Year

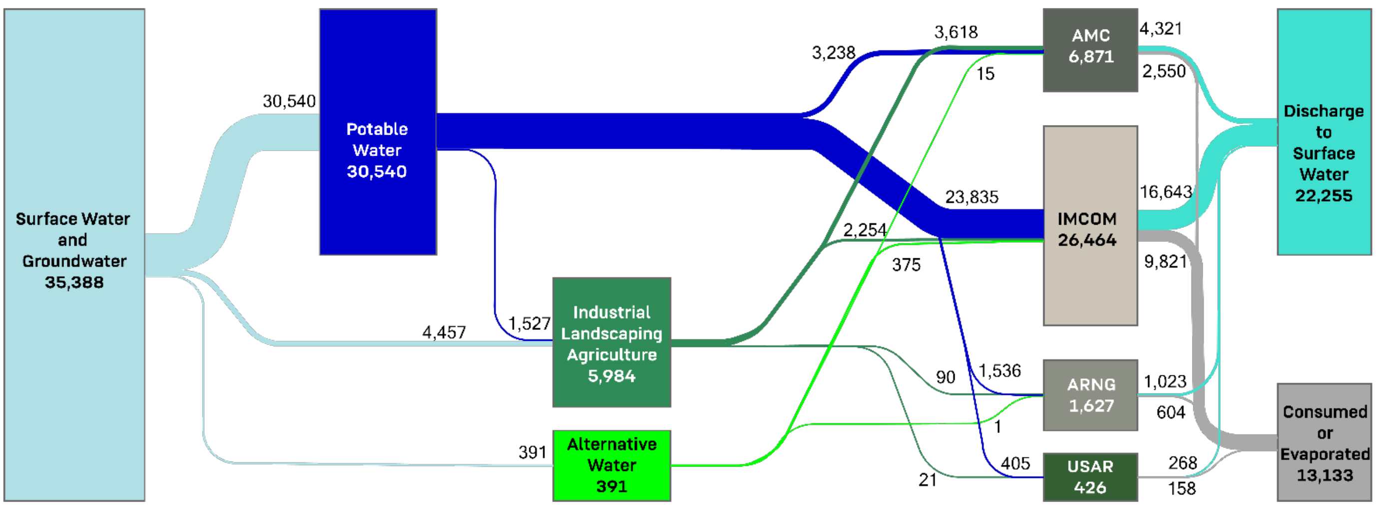

Figure 2: Army Installation Water Sankey Diagram

Consistent with the energy reporting required by EPAct 2005, Army installation water is the water consumed in Federal buildings used by the Department of the Army at installations in the CONUS, enduring locations OCONUS, and sites managed by the ARNG and USAR.

The data used to create this diagram is from the FY19 Army Annual Energy Management and Resilience Report (AEMRR), DoD Army Supplemental Workbook, and the Federal Energy Management Program (FEMP) Workbook. Industrial, Landscape and Agriculture (ILA) water reported in the AEMRR is non-potable water collected on-site from freshwater sources. Industrial water is used to aid in industrial processes such as cooling, washing, and manufacturing. Landscaping water is used for the controlled application of water to outdoor spaces to supplement water demand not satisfied by natural precipitation. Non-potable landscaping water reported in AEMRR has been supplemented by an independent HQDA data call related to potable water used in landscaping. Agricultural water is used for irrigation and other uses related to a Federal agency testing and development of agricultural products. Alternative water reported in the AEMRR is untreated water generated on-site from supplies other than freshwater sources. Additional data used for the estimating water source and end use is based on work completed in 2005 by the Department of Energy and Lawrence Livermore National Laboratory (LLNL), available: https://flowcharts.llnl.gov/commodities/water.

Conclusion

The above Sankey Diagrams reveal that there are additional opportunities for energy and water efficiency initiatives and projects. By focusing attention on the sources of wasted energy (REJECTED ENERGY) and water (DISCHARGE TO SURFACE WATER), Sankey diagrams help installation energy managers and others make the case for implementing conservation and efficiency measures.

Sankey diagrams help us look at that data from another perspective and can provide thought-provoking insights. By creating visualizations of energy and water use, the Army hopes to inspire greater awareness of the value of conservation and the importance of efficiency. While some of the energy and water consumption illustrated on the Sankey diagrams cannot be controlled directly by the Army, it points managers to energy and water conservation and efficiency activities that could be – from simple behavior change efforts like turning off the lights to systems design projects like retrofitting existing systems or equipment. Sankey illustrations can help guide those discussions toward where to focus first and how to get the greatest return on investments to improve energy and water efficiency and cost.

The intent is to show how much of the energy and water we generate or purchase are wasted. We use the information in the Sankey diagrams, along with other data, to encourage overall conservation efforts and highlight opportunities to increase system and equipment efficiency.

By increasing its focus on identifying ways to improve conservation and efficiency – as the Sankey diagrams help us to do – the Army is working to ensure installation energy and water infrastructure supporting critical missions in the Strategic Support Area is resilient, efficient, and affordable. We hope this information inspires each of us to take action that results in the Army consuming less energy and water and to better utilize the energy and water we consume across all Army installations.

SUGGESTIONS TO INCREASE EFFICIENCY

- *Turn off the lights when you will be out of a room for more than five minutes*
- *Complete comprehensive energy and water evaluations to ensure all installation buildings are evaluated every four years…and implement life cycle cost effective solutions*
- *Achieve Leadership in Energy Environmental Design (LEED) Silver, or better, for new construction; construct and maintain buildings to achieve lowest life cycle costs; and ensure Operations & Maintenance (O&M) costs are included into life cycle analysis*
- *Monitor building control systems from a single location at each garrison to measure, manage, compare and report on buildings' energy and water usage*
- *Consider incorporating the organizing principles of the International Organization for Standardization (ISO) 50001 (Energy Management) for persistent energy savings*
- *Optimize building performance by conducting building commissioning, building retuning, boiler tune-ups, and regular reviews of equipment performance data*
- *Participate in utility or regional transmission organizations' demand response programs*
- *Reduce energy demand at critical facilities and use cost-reduction strategies to address plans and actions that do not require capital investment and lead to reduced energy and water-related costs, including utility rate renegotiation*

# # #

For additional information, please contact the U.S. Army Chief of Public Affairs, Media Relations Division, at 703-697-5344.