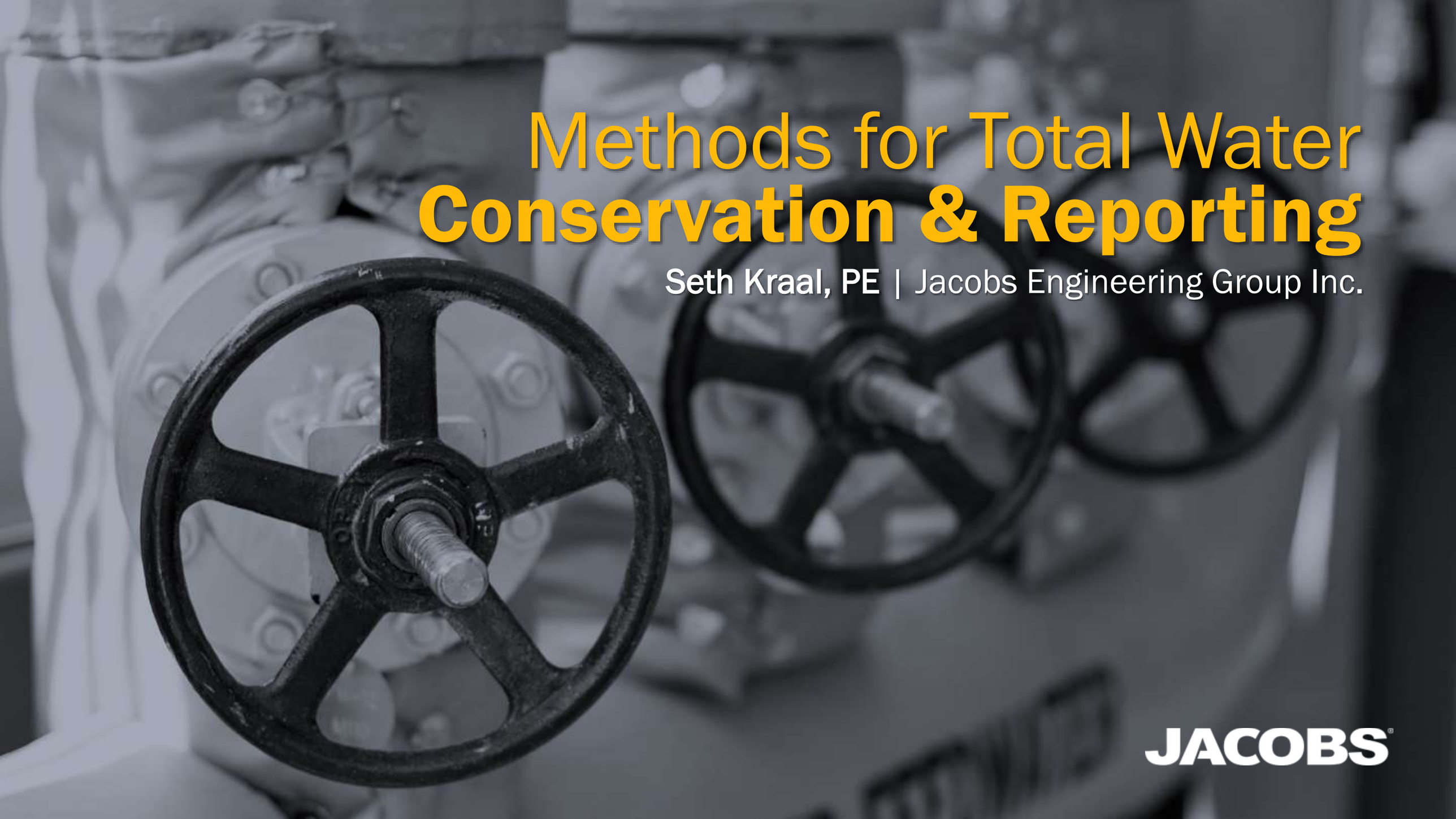

Methods for Total Water **Conservation & Reporting**

Seth Kraal, PE | Jacobs Engineering Group Inc.

JACOBS

Where is **Water?**

PLANNING

Water conservation receives a small fraction of attention from our planning efforts

COSTS

Water prices are geographically specific but typically range from $10 – $30 per kGal for water and sewer combined service

FUTURE

Water rate inflation is between 4 - 9% nationally, with many areas facing water shortages in the near-term

Water Used for **Electric Generation**

161 BILLION
GALLONS OF WATER
PER DAY
withdrawn for electrical generation
in 2010 alone

2 GALLONS
OF WATER EVAPORATED FOR EVERY
KWH PRODUCED

Source **Water / Power Ratio**

Source Water Ratio

The water consumption of the energy mix between different forms of generation in a particular area

US Averages

Min: 0.0 gal/kWh (MA / RI)

Avg: 2 gal/kWh

Max: 72.6 gal/kWh (SD)

Where Are We **Using the Water?**

Typical district energy water consumption

- Electrical consumption
- HVAC and electrical generation Heat rejection
- Hydronic system make-up

Where Does **District Energy** Fit into a Solution?

Eliminates distribution losses

More water-efficient electrical generation

Thermal load shifting and air cooled equipment

Infrastructure investments in high efficiency heating and cooling systems

Future opportunities

Planning and reporting

Eliminating Distribution Losses + **Water Efficient Generation**

Distribution system losses typically range from **4% to 9%** with corresponding losses of source water

Distributed generation in CHP applications can **replace water intensive, grid electricity** with water efficient local generation

Thermal Load Shifting / Energy Efficient Systems

AIR COOLED EQUIPMENT
can reduce total water consumption in some areas (source water ratio)

THERMAL LOAD SHIFTING
can utilize ambient relief for site or source water savings

CAPITAL INVESTMENT
in long-term or “forever” facilities incentivizes long-term water planning

Water for **Make-up**

Hydronic Heating and Cooling Systems → **HIGH**
Return / supply volume

High-efficiency Steam Heating Systems → **MEDIUM**
Return / supply volume

Aged Steam Heating Systems → **LOW**
Return / supply volume

Future Considerations

- ✓ Hybrid wet/dry heat rejection
- ✓ Air cooled cooling and generation systems
- ✓ Implementation of AHU condensate recovery
- ✓ Steam to hot water system conversions
- ✓ Sewer/wastewater heat rejection

Planning and Reporting

Most district energy systems save water

REPORT THESE SAVINGS!

Source **Water / Power Ratio**

Source Water Ratio

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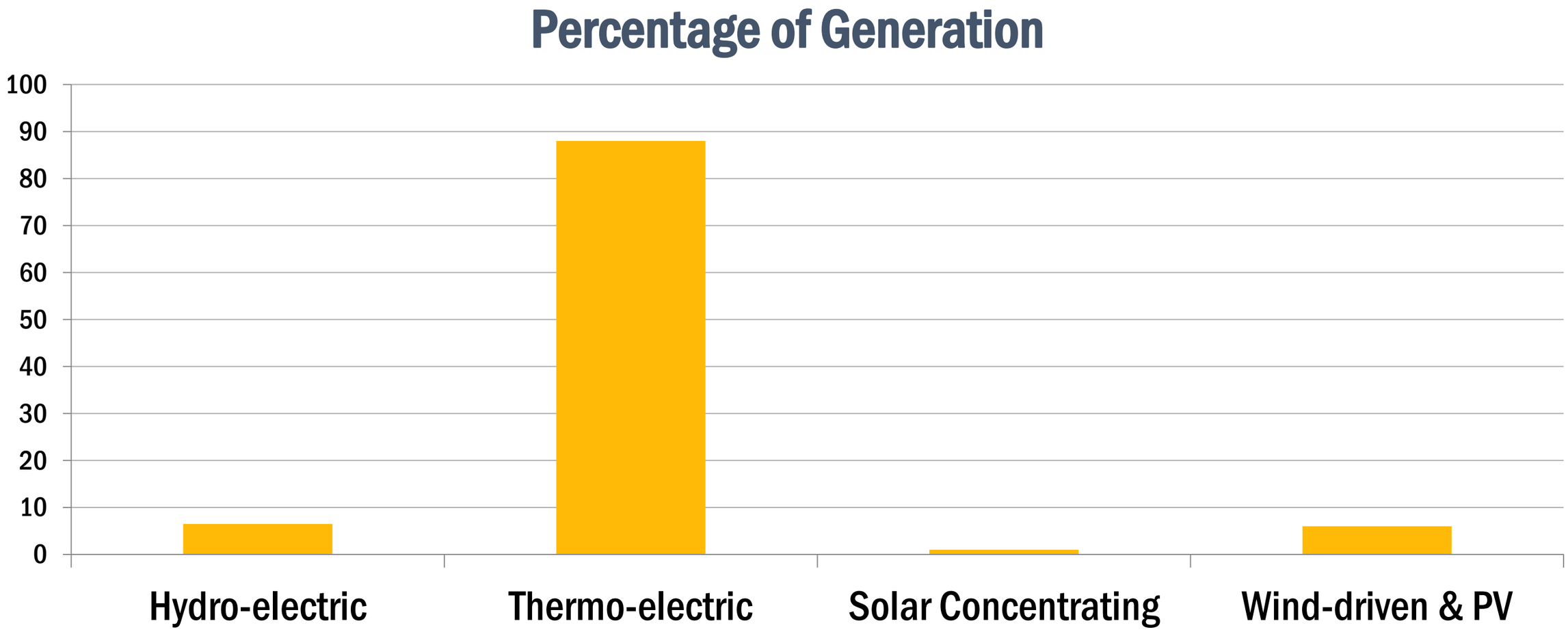
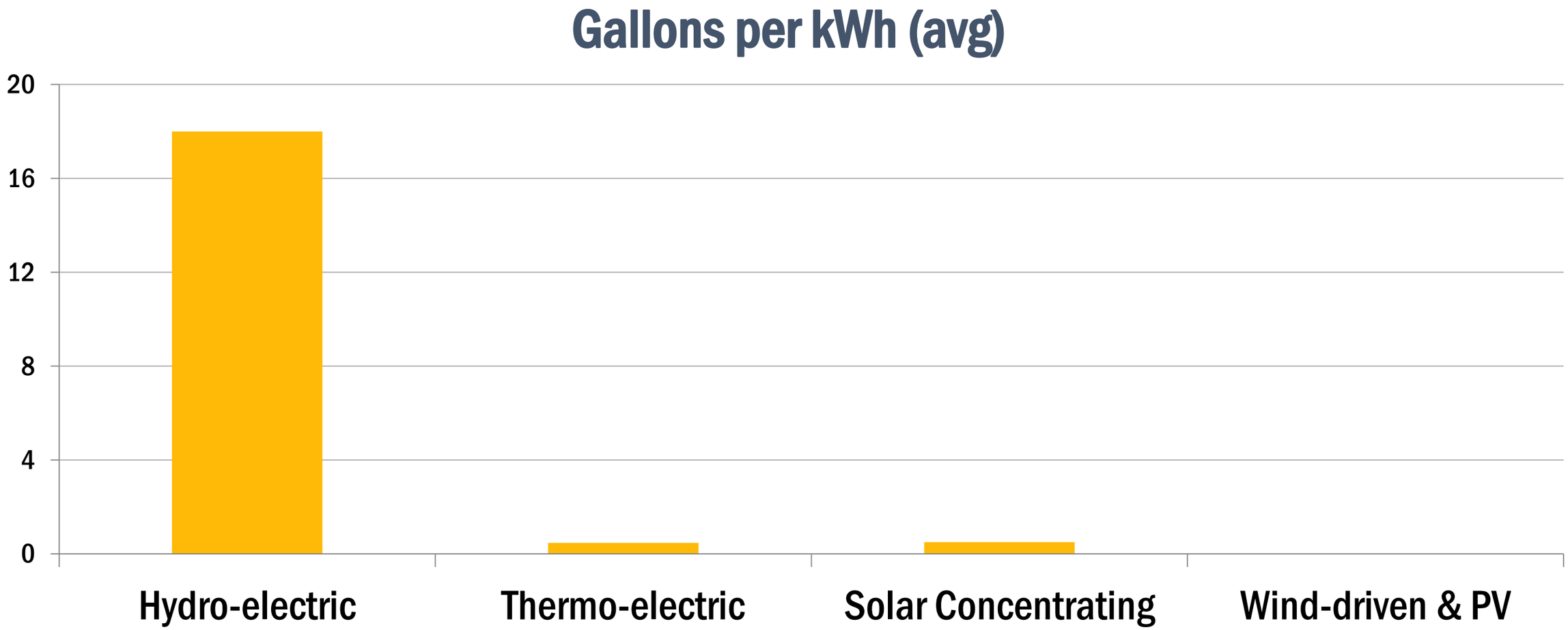
Water Use by Generation Type



Water Use by Generation Type



Water Use in PV and Wind Energy

Wind energy is generally accepted to use no water during the production of electricity

PV arrays typically require some water to wash the panels to maintain the array output; consumption rarely rises above 0.25 gallons per kWh

Water Use for Condenser Heat Rejection

Heat-driven electrical generation systems require some heat rejection:

Cooling Towers	**2 - 10** gallons / kWh
Once-Through Cooling	**1 - 4** gallons / kWh
Pond Cooling	**1 - 8** gallons / kWh
Dry-Cooling Cycles	**0.3 - 1** gallon / kWh

Water Use in Solar Concentrating

Concentrating solar power arrays (trough & tower) use water for heat rejection and cleaning reflectors

Cooling pond and once-through cooling are typically not an option for these fields due to **environmental and site location conditions**

Water Use for Hydro-generation

Several methods exist for
estimating reservoir evaporation

Regardless of the method of calculation, bodies of water with **proportionally large surface areas** are assumed to allow prodigious evaporation

Water Use for Hydro-generation

Several methods exist for **estimating reservoir evaporation**

Hydro-electric power

consumes up to 150 gal/kWh

Regardless of the method of calculation, bodies of water with **proportionally large surface areas** are assumed to have high evaporation

but

averages about 18-20 gal/kWh

Did We Really **Save Water?**

Typically, yes but not always. The water not released to generate electricity can be utilized (from the reservoir) for other purposes.

It's necessary to **understand the energy mix** in your area and totality of benefits provided by local dams and reservoirs to interpret the results

Data sources

Data Sources

U.S. Energy Information Administration

- https://www.eia.gov/tools/faqs/faq.php?id=427&t=3

Consumptive Water Use for US Power Production; 2003

- P. Torcellini, N. Long, and R. Judkoff
- http://www.nrel.gov/docs/fy04osti/33905.pdf

A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies; 2011

- Jordan Macknick, Robin Newmark, Garvin Heath and KC Hallett
- http://www.nrel.gov/docs/fy11osti/50900.pdf

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