We’ll be starting in just a few minutes….

Visit our new Online Learning Series webpage on the Solution Center where you can see the schedule of upcoming webinars, RSVP, and access previously recorded webinars on other energy management topics.
Eli Levine
U.S. Department of Energy
## Better Plants Online Learning Series

### NEW! Better Plants Online Learning Series

Starting Thursday, April 16, 2020  |  1:00 pm US-ET

[CLICK HERE TO LEARN MORE](#)

<table>
<thead>
<tr>
<th>Webinar Topic</th>
<th>Speaker</th>
<th>Date</th>
<th>Time</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Better Plants Town Hall</td>
<td>Eli Levine (DOE), feat. Al Hildreth (General Motors)</td>
<td>04/16/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>2. Basics of Energy</td>
<td>Thomas Wenning (ORNL)</td>
<td>04/23/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>3. Lighting, HVAC, and Building Envelope</td>
<td>Thomas Wenning (ORNL)</td>
<td>04/29/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>4. Resources You Should Know: USDA Rural Development Programs and the Department of Commerce Manufacturing Extension Partnership</td>
<td>Venus Welch-White (USDA) and David Stilen (NIST-MEP)</td>
<td>05/07/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>5. Compressed Air Systems</td>
<td>Thomas Wenning (ORNL)</td>
<td>05/14/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
<tr>
<td>6. Water Efficiency</td>
<td>Sachin Niimbalkar (ORNL)</td>
<td>05/21/20</td>
<td>1:00 pm US-EST</td>
<td>Register</td>
</tr>
</tbody>
</table>
JUNE 8–11
2020 SUMMIT
A Virtual Leadership Symposium

Learn more and register: betterbuildingssolutioncenter.energy.gov/summit
If you called in and are using the Phone Audio option for this webinar, please switch to the Computer Audio option on your GoToWebinar control panel.

Having trouble with audio? Let us know in the Questions box and a member of our team will help you via chat.
Online Learning Training Program

The Basics of Energy
April 23, 2020

Thomas Wenning, PE
Wei Guo, PhD, PE
Online Training Program

- **Goal**
  - Learn the basics to build the foundation!

- **Upcoming Training Sessions**
  1. Basics of Energy
  2. Lighting and HVAC systems and building envelope
  3. Resources You Should Know: USDA Rural Development Programs and the Department of Commerce Manufacturing Extension Partnership
  4. Compressed air systems
  5. Water efficiency
Housekeeping

- Slides are Available
- Webinars are Recorded
  - Links will be sent out after each webinar
- Send in your questions!
- Questions/Comments
  - Thomas Wenning - wenningtj@ornl.gov
  - Wei Guo - guow@ornl.gov
Better Buildings, Better Plants

- **What is Better Plants?** A voluntary, public-private partnership program for manufacturers and industrial organizations

- **Through Better Plants:**
  - Partners set long-term efficiency goals
  - Receive technical assistance, networking platforms and national recognition

- Manufacturers have two opportunities to engage in Better Plants:
  1. Broader-based *Program* level
  2. Higher-level *Challenge*

Productivity + Cost Savings = Competitiveness
Why Partner with Better Plants?

Technical Assistance
- **Technical Account Manager**: navigate program and access resources
- **In-Plant Trainings**: expert instructors come to your plant
- **Resources**: Diagnostic & Software Tools/Industrial Assessment Centers/CHP TAPs/Water Savings primer
- **Supply Chain Engagement**: resources to advance supplier energy efficiency

National Recognition
- **Awards** for Goal Achievers
- **Better Project/Better Practice Awards**

Peer-to-Peer Networking Opportunities
Outline

- Why Energy Efficiency?
- Energy Codes and Standards
- Energy Accounting
  - Energy Types
  - Energy Related Units and Unit Conversions
- How to Read Utility Bills
  - Utility Rates
  - Electricity and Natural Gas
- Energy Benchmarking
- Energy Assessments
  - Steps
  - Instruments and Software Tools
Why Energy Efficiency?

- **Environmental regulations**
  - Reduce greenhouse gas emission

- **Economic competitiveness**
  - Reduce energy costs
  - Reduce equipment maintenance costs

- **Energy security**
  - Reduce reliance on power grid
  - Reduce production interruption
  - Improve manufacturing process reliability
Energy Codes and Standards

- ANSI/ASHRAE/IES 90.1 and 90.2
  - Commercial Building Energy Performance
- ASHRAE 62.1
  - Indoor Ventilation Requirements
- ASHRAE 55
  - Thermal Environmental Conditions for Human Occupancy
- ASHRAE 211
  - Commercial Building Energy Audits
- ASME Energy Assessment Standards
  - Process Heating (EA-1), Pump (EA-2), Steam (EA-3), Compressed Air (EA-4)
Energy Accounting

- Recognize different energy and fuel types
  - Electricity, natural gas, propane, diesel fuel, etc.

- Understand energy related units
  - kW, kWh, Btu, MMBtu, therm, MCF, HP

- Perform energy unit conversions
  - For example, 1kWh = 3,412 Btu
Some Common Energy Related Units

- **1 kWh**: one kilowatt of power sustained for one hour.
- **1 Btu**: the amount of heat required to raise the temperature of one pound of water by one degree F.
- **1 CCF Natural Gas**: 100 ft$^3$ natural gas.
- **1 MCF natural gas**: 1,000 ft$^3$ natural gas.
- **1 Therm**: 100,000 Btu; approximately the energy equivalent of burning 1 CCF.
- **1 Watt**: the power of the current flow of one ampere with voltage of one volt.
Unit Conversions

- 1 kWh = 3,412 Btu
- 1 MWh = 1,000 kWh
- 1 ft³ natural gas = ~1,020 Btu
- 1 CCF natural gas = 100 ft³ natural gas = ~100,000 Btu
- 1 MCF natural gas = 1,000 ft³ natural gas = ~1,000,000 Btu
- 1 MMBtu = 1,000,000 Btu
- 1 therm = 100,000 Btu
- 1 dekatherm = 10 therms = 1,000,000 Btu
- 1 Quad = 10^{15} Btu
- 1 HP = 746 W = 0.746 kW
- 1 Boiler HP = 33,475 Btu/hr
Unit Conversions

- 1 ft$^3$ natural gas = ~1,020 Btu
- 1 gallon propane = 91,000 Btu
- 1 gallon gasoline = 125,000 Btu
- 1 gallon diesel = 139,000 Btu

- 1 gallon #2 fuel oil = 140,000 Btu
- 1 barrel residual fuel oil = 6,287,000 Btu
- 1 barrel crude oil = 5,722,000 Btu

- 1 ton coal (…type...) = 125,000 Btu
- 1 cord wood (avg dry) = 30,000,000 Btu
Electricity Rate Structure

- Most **rate structures** can be found on **utility companies’ web page**

- **4 Main Utility Charges**
  - Meter **Connection fee**
  - Demand charge (kw or kVA)
  - Consumption Charge (kWh)
  - Power factor penalty

- **Taxes, fees and riders**

- **Owning your transformer**
  - Primary versus Secondary Rate structure
Demand vs Consumption

- **Demand**
  - How much you need at any given moment

- **Consumption**
  - How much you’ve used over time
Power Factor

Picture Source: https://electricalsynergy.edublogs.org/
Transformers reduce the voltage of electricity supplied to plant.

**Primary Service**: customer owns and maintains the transformer

**Secondary Service**: utility owns and maintains the transformer

**Lower electricity rates for primary service**, since the customer must purchase and maintain the transformer

**Typically advantageous for customer to purchase transformer when demand**

> 1,000 kVA
Ex: Electricity Rate Structure

- Connection Fee: e.g. $50/mon
- Energy Charge: e.g. $0.05/kWh
- Demand Charge: e.g. $6.5/kW/month
- Low Power Factor Penalty: e.g. $0.3/kvar-month
- Fuel adjustment
- Other Charges
- Tax
Read electricity bills

### Mail Payments To

<table>
<thead>
<tr>
<th>Name/Service Address</th>
<th>For Inquiries Call</th>
<th>Account Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duke Energy</td>
<td>1-866-509-4914</td>
<td>XXXX</td>
</tr>
<tr>
<td>For Account Services, please contact</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mail Payments To</th>
<th>Account Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO Box 1326</td>
<td>Payments after Aug 15 not included</td>
</tr>
<tr>
<td>Charlotte, NC 28201-1326</td>
<td>Last payment received Aug 01</td>
</tr>
<tr>
<td></td>
<td>Bill prepared on Aug 15, 2018</td>
</tr>
<tr>
<td></td>
<td>Next meter reading Sep 13, 2018</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Meter Number</th>
<th>Reading Date From</th>
<th>Reading Date To</th>
<th>Days</th>
<th>Meter Reading Previous</th>
<th>Meter Reading Present</th>
<th>Multi</th>
<th>Usage</th>
<th>Actual kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elec 106917356</td>
<td>Jul 16</td>
<td>Aug 14</td>
<td>29</td>
<td></td>
<td>2,414,914</td>
<td></td>
<td></td>
<td>5,913.60</td>
</tr>
</tbody>
</table>

### Current Billing

<table>
<thead>
<tr>
<th>Usage - 2,414,914 kWh</th>
<th>5,913.60 kW</th>
<th>4,732.80 kVar</th>
<th>$203,697.80</th>
<th>Duke Energy - Rate LPN0</th>
<th>Current Electric Charges</th>
<th>$203,697.80</th>
</tr>
</thead>
</table>

<p>| Current Billing       | Amount Due - Previous Bill | $212,403.89 |
|                       | Payment(s) Received        | 212,403.89cr |
|                       | Balance Forward            | 0.00         |
|                       | Current Electric Charges   | 203,697.80   |
|                       | Other Credits/Charges      | 10.00        |
|                       | PwrSh Capacity Premium     | 5,186.33cr   |
|                       | Current Amount Due         | $198,521.47  |</p>
<table>
<thead>
<tr>
<th>Electric</th>
<th>Duke Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter: 106917356</td>
<td>Rate LPNO - Low Load Factor Pri Srv</td>
</tr>
<tr>
<td>kWh Usage: 2,414,914</td>
<td></td>
</tr>
<tr>
<td>Actual kW: 5,913.60</td>
<td>Connection Charge $75.00</td>
</tr>
<tr>
<td>Actual kVA: 7,574.30</td>
<td>Demand Charge 24,304.90</td>
</tr>
<tr>
<td>Billed Kvar: 4,732.80</td>
<td>Energy Charge 86,922.41</td>
</tr>
<tr>
<td>Power Factor: 78.1%</td>
<td>KVAR Charge 1,135.87</td>
</tr>
<tr>
<td>Date of Peak: 08/03/2018</td>
<td>Total Current Electric Charges $203,697.80</td>
</tr>
<tr>
<td>Time of peak: 12:00:00</td>
<td></td>
</tr>
<tr>
<td>Jul 16 - Aug 14</td>
<td></td>
</tr>
<tr>
<td>29 Days</td>
<td></td>
</tr>
</tbody>
</table>

- **Rider 71 - Clean Coal Adjustment**: 12,576.87
- **Rider 72 - Federally Mand Cost Adj**: 272.89
- **Rider 73 - Renewable Energy**: $203,697.80
Read Electricity Bill

Explanation of Other Charges/Credits

<table>
<thead>
<tr>
<th>Other Credits/Charges</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>En-Focus Program Charge</td>
<td>$10.00</td>
</tr>
<tr>
<td>Total Other Credits/Charges</td>
<td>$10.00</td>
</tr>
</tbody>
</table>

Electric Usage

- Calculations based on most recent 12 month history
- Total Usage: 26,468,935
- Average Usage: 2,372,411

<table>
<thead>
<tr>
<th></th>
<th>JUL</th>
<th>AUG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric</td>
<td>2414914</td>
<td>2414914</td>
</tr>
<tr>
<td>Oct</td>
<td>205474</td>
<td>205474</td>
</tr>
<tr>
<td>Sep</td>
<td>2650690</td>
<td>2650690</td>
</tr>
<tr>
<td>Aug</td>
<td>2610010</td>
<td>2610010</td>
</tr>
<tr>
<td>Dec</td>
<td>2274697</td>
<td>2274697</td>
</tr>
<tr>
<td>Mar</td>
<td>2191495</td>
<td>2191495</td>
</tr>
<tr>
<td>Apr</td>
<td>2320291</td>
<td>2320291</td>
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<tr>
<td>May</td>
<td>2485930</td>
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<tr>
<td>Jun</td>
<td>2544158</td>
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<tr>
<td>Jan</td>
<td>1919117</td>
<td>1919117</td>
</tr>
<tr>
<td>Feb</td>
<td>2319414</td>
<td>2319414</td>
</tr>
<tr>
<td>Mar</td>
<td>2273213</td>
<td>2273213</td>
</tr>
</tbody>
</table>
Natural Gas Rate Structure

- 2 primary components to Natural Gas
  - Wholesale (Natural Gas commodity)
  - Transportation and distribution fee

- Procurement/Commodity Cost
  - Gas Cost: e.g. $0.3/therm

- Distribution Cost
  - Customer Charge: e.g. $250/mon
  - Distribution Charge: e.g. First 2500 therms @ $0.1609 per therm; Over 2500 therms @ $0.0729 per therm
  - Other Charges: e.g. Universal service charge

- Tax
### Billing Information

**Billing Date:** Apr 4, 2019  
**Date Due:** Apr 21, 2019  
**Amount Due:** $4,814.67

**Previous Bill Amount:** $5,144.54  
**Payment(s) Received:** $5,144.54  
**Balance Carried Forward:** $0.00  
**Charges This Period:** $4,814.67  
**Total Amount Due:** $4,814.67

### Detailed Account Activity

#### Gas Meter Information

<table>
<thead>
<tr>
<th>Number</th>
<th>Service Period From To</th>
<th>Number of Days</th>
<th>Beginning</th>
<th>Ending</th>
<th>CCF Used</th>
<th>Pressure Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>N00000000</td>
<td>03/01/19 - 04/01/19</td>
<td>31</td>
<td>10138230A</td>
<td>10240141A</td>
<td>53471</td>
<td>1</td>
</tr>
</tbody>
</table>

#### Gas Transportation Service
- **Throughout Charges:** $4,285.83  
- **Customer Facilities Charge:** $200.00  
- **Universal Service Fund Charge:** $5.50  
- **Compliance/Supplier Imprvmt Adj:** $290.00  
- **Gas Cost Adjustment:** $33.46

**Total Current Charges - Rate Schedule 245:** $4,814.67

### Distribution Detail
- 250 Dekatherms @ $1.509 per Dekatherm  
  **Total:** $382.25
- 5,327 Dekatherms @ $0.729 per Dekatherm  
  **Total:** $3,983.38

**Total Distribution Charges:** $4,365.63

**Distrib. Plus Trans. Service:** $4,814.67  
**Total Bill:** $9,170.30

---

**NOTE:** This is an example of a natural gas bill. Actual bills may vary.
Benefits of Utility Bill Analysis

- Determine if you are on the **correct rate structure**
- Check for **billing errors** (they do happen!)
- Identify **Power Factor correction** opportunities

https://www.jingdaily.com/
Electrical Cost Saving Opportunities

- **Rate Structure**
  - Switch to or negotiate electric rate structure with lower overall costs
  - Enroll in demand response program
- **Billing Errors**
  - Reconcile billing error with utility
- **Meter Consolidation**
  - Consolidate electrical meters
- **Purchasing Transformer**
  - Purchase transformer and switch to primary service
- **Power Factor Correction**
  - Correct power factor by downsizing over-sized motors
  - Correct power factor by adding capacitors
- **Demand Saving Potential**
  - Reschedule operation of electrical equipment to reduce peak demand
  - Use control equipment to shed loads to manage peak demand
Energy Benchmarking

Benchmarking is the practice of comparing the measured performance of a device, process, facility, or organization to itself, its peers, or established norms, with the goal of informing and motivating performance improvement.

- Wikipedia
Energy Benchmarking Tools

Energy Intensity
- Commercial and Residential Buildings
  - Total Energy Consumption/Total Buildings Square Footage
- Industrial Buildings
  - Total Energy Consumption/Total Production

EPA Energy Star
- Energy Performance Indicators for Plants
  - Developed for 18 specific industries
Goals of Energy Assessments

- Identify energy types and cost
- Understand how energy is being used
- Identify energy savings opportunities
  - Improved operation
  - New equipment, new processes, or new technologies
- Perform economic analysis on these energy savings opportunities
Types of Assessment

- ASHRAE Levels 1, 2, 3
- ASME system standards for assessments
  - Process Heating (EA-1), Pump (EA-2), Steam (EA-3), Compressed Air (EA-4)
- Treasure Hunts & Kaizens
- IAC Energy Assessment Database
  - Data for thousands of assessments and recommendations
  - https://iac.university
Steps for On-site Energy Assessments

1. Identify **facility layout** and **operational schedule**
2. Understand the **material flow** and **manufacturing process**
3. Identify **all large end-users**, such as, compressed air, pumps, fans, etc.
4. Collected **operational data** for these large energy end-users
5. Review and discuss the **operation of large energy end-users**
6. Identify **energy savings opportunities** for these large energy end-users
7. Calculate **energy savings** from identified opportunities
8. Prepare the energy assessment **report**
Instruments for Energy Assessments

- **Electrical system**
  - Insulated gloves
  - Multimeter – volt., amp., watt
  - Power meter – Watt, Var, PF
  - Light meter – light level
Instruments for Energy Assessments

- Temperature Measurements
  - Thermometer
  - Portable electronic thermometer
  - Thermocouple probe
  - Infrared Camera
Instruments for Energy Assessments

- Pressure Measurements
  - Manometer
  - Bourdon Gauge
  - Pressure Transducer
Instruments for Energy Assessments

- **Combustion Measurement**
  - Combustion Analyzer
  - Combustion Efficiency
  - Oxygen \( (O_2) \), Carbon monoxide \( (CO) \), Carbon dioxide \( (CO_2) \),
  - Inlet Temperature, Flue,
  - Temperature, Draft, Excess Air
Instruments for Energy Assessments

- **Velocity and Flow Rate Measurements**
  - Pitot Tube
  - Rotating Vane Anemometer
  - Hotwire Anemometer
  - Ultrasonic Flow Rate
Instruments for Energy Assessments

- **Leak Detection**
  - Compressed Air Ultrasonic Leak Detector
  - Sonic Imager
  - Steam Trap Leak Detector
Instruments for Energy Assessments

- Data Loggers
  - Light on-off
  - Motor on-off
  - Temperature & RH
  - General channel
Instruments for Energy Assessments

- Personal Protection Equipment
  - Safety Glasses
  - Steel-toe Shoes
  - Hard Hat
  - Ear Protection
Software Tools for Energy Assessments

- MEASUR Tool Suite
- Energy Treasure Hunt Toolkit
- Pumps, Fans, Process Heat, Steam, Compressed Air, Motors
- 45+ Simple Calculators

https://www.energy.gov/eere/amo/software-tools
Economic Analysis

- **Simple Payback (SP)**
  - Investment Cost/Annual Savings

- **Return on Investment (ROI)**
  - Annual Savings/Invest

- **Hurdle Rate**
  - The rate determined to be the minimum allowed for investments approved by company
    - Typical – 50% ; Best in class (25%)

- **Lifecycle Assessment or Net Present Value (NPV)**
  - Best for evaluating cost of new equipment versus lifetime operational costs

Image Source: https://online.stanford.edu/
7 Major Systems to Consider

1. Lighting systems
2. HVAC systems
3. Building envelope
4. Pump and fan systems
5. Compressed air systems
6. Process heating and cooling systems
7. Building automation system
Upcoming Training Sessions

1. **Lighting** and **HVAC** systems and building envelope
2. **Resources You Should Know:**
   - USDA Rural Development Programs and the Department of Commerce **Manufacturing Extension Partnership**
3. **Compressed air** systems
4. **Water** efficiency

https://www.ingersollrandproducts.com/

https://www.commercialarchitecturemagazine.com
Homework

1. What was your **annual energy consumption** last year for Electricity and Natural Gas?

2. What were the **annual energy costs** for Electricity and Natural Gas?

3. What is the **average rate** for each energy source?
   
   a. Hint: = ($ cost) / consumption
Want to join the conversation?

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Type any questions or comments into the [Questions box](#).
BETTER BUILDINGS

Better Buildings is an initiative of the U.S. Department of Energy (DOE) designed to improve the lives of the American people by driving leadership in energy innovation. Through Better Buildings, DOE partners with leaders in the public and private sectors to make the nation’s homes, commercial buildings and industrial plants more energy efficient by accelerating investment and sharing of successful best practices.
Better Plants Online Learning Series

BETTER PLANTS TOWN HALL
Thr, Apr 16, 2020 | 1:00 - 2:00 PM ET

BASICS OF ENERGY
Thr, Apr 23, 2020 | 1:00 - 3:00 PM ET

LIGHTING, HVAC, AND BUILDING ENVELOPE
Wed, Apr 29, 2020 | 1:00 - 3:00 PM ET

RESOURCES YOU SHOULD KNOW:
USDA Rural Development Programs & the Dept. of Commerce
Manufacturing Extension Partnership
Thr, May 7, 2020 | 1:00 - 2:00 PM ET

COMPRESSED AIR SYSTEMS
Thr, May 14, 2020 | 1:00 - 3:00 PM ET

WATER EFFICIENCY
Thr, May 21, 2020 | 1:00 - 2:00 PM ET
Additional Questions?

Please Contact Us

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@BetterBldgsDOE

Better Buildings Solution Center
http://betterbuildingssolutioncenter.energy.gov/better-plants

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