Energy Management System (EnMS) Expert Training

UNIDO International Energy Efficiency and EnMS Expert

Module 2 – Operations – Day 1

Based on the contents of the UNIDO Practical Guide for Implementing and Energy management System
### Module 2 – Operations – Day 1

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Exercise - Report on progress

- What is your target reduction in kWh next year for each energy source in your scope?
- How did you decide this target?
- What are your action plans to achieve this target?
- How will your EnPIs show progress against this target?
See you in 15 minutes!
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Force Field Analysis

Exercise: Use Force Field Analysis to identify solutions to any problems encountered to date
Force field analysis

(Lewin, 1951)

Energy Performance Opportunity

(EnMS System)

- Significant Improvement potential
- Low investment
- Good Training
- CSR
- Energy Cost Increase

- Knowledge of plant
- It is working OK Now
- We have no money for Investment
- What improvement Potential?
- I haven't time for this FAD?
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Planning & DO

- How much energy am I using?
- Where am I using it?
- What Legal requirements are related to my energy use?
- What Other requirements are related to my energy use?
- Which are significant users?
- What is driving it?
- Who is influencing its use?
- Do I need to have an energy audit?
- System Optimization
- Renewable energy options
- Are there legal or other requirements?
- Develop baseline & indicators
- Set objectives and targets
- Action Plans
## Significant Energy Uses

**ENERGY BALANCE REPORT**

**Mine**

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>Electricity GJ</th>
<th>Fossil Fuel GJ</th>
<th>Total GJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunging</td>
<td>46,205</td>
<td>0</td>
<td>46,205</td>
</tr>
<tr>
<td>Compressed Air</td>
<td>1,935</td>
<td>0</td>
<td>1,935</td>
</tr>
<tr>
<td>Steam System</td>
<td>181</td>
<td>19,356</td>
<td>19,537</td>
</tr>
<tr>
<td>Tank mixing</td>
<td>11,768</td>
<td>0</td>
<td>11,768</td>
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<tr>
<td>High shear</td>
<td>56,905</td>
<td>0</td>
<td>56,905</td>
</tr>
<tr>
<td>Pumps - Water, sl</td>
<td>17,057</td>
<td>0</td>
<td>17,057</td>
</tr>
<tr>
<td>Other</td>
<td>16,834</td>
<td>0</td>
<td>16,834</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>150,885</strong></td>
<td><strong>0</strong></td>
<td><strong>150,885</strong></td>
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</table>

The chart on the right illustrates the distribution of energy usage across different systems.
# SEU Sankey Diagram

## U.S. Department of Energy

### Energy Efficiency and Renewable Energy

**Plant Name:** Test Steel Plant - US

**Furnace Name:** Ladle heater 1

### Furnace heat input

<table>
<thead>
<tr>
<th>Gross fuel heat input</th>
<th>Available heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>18,350,152 Btu/hr</td>
<td>12,764,373 Btu/hr</td>
</tr>
</tbody>
</table>

### Flue gas losses

<table>
<thead>
<tr>
<th>Component</th>
<th>Btu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,585,799 Btu/hr</td>
<td></td>
</tr>
<tr>
<td>5,595,793 Btu/hr</td>
<td></td>
</tr>
</tbody>
</table>

### Other losses

<table>
<thead>
<tr>
<th>Component</th>
<th>Btu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>241,205 Btu/hr</td>
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</table>

### Wall losses

<table>
<thead>
<tr>
<th>Component</th>
<th>Btu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>814.303 Btu/hr</td>
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</table>

### Opening losses

<table>
<thead>
<tr>
<th>Btu/hr</th>
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<tbody>
<tr>
<td>552,641 Btu/hr</td>
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</table>

### Atmosphere losses

<table>
<thead>
<tr>
<th>Btu/hr</th>
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<tbody>
<tr>
<td>248,000 Btu/hr</td>
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### Water cooling losses

<table>
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<tbody>
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<td>841,216 Btu/hr</td>
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### Fixture/conveyor losses

<table>
<thead>
<tr>
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<td>567,000 Btu/hr</td>
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### Useful output (heat to load)

<table>
<thead>
<tr>
<th>Btu/hr</th>
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<tr>
<td>9,200,000 Btu/hr</td>
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Connections to Significance

- Competence, training and awareness
- Operational control
- Procurement
- Objectives, targets and action plan
- Monitoring, measurement and analysis

**Significant energy uses**
Significant Energy Uses-Connections
What does this mean to me?

- Designation of an energy use as *Significant* will have profound effects on the implementation and operation of an Energy Management System.

Connections to significance exist throughout the EnMS and must be addressed. Specific requirements include operator competence and training, procurement, operational controls, monitoring, measuring and analysis and objectives, targets, and action plans.
Recall: Simple Steam System
Steam System Performance
A profile of losses operating a 500 hp boiler with NG at 60% firing rate (annual fuel bill = $800,000)

Boiler Losses
- Stack Losses 18% $144,000
- Blowdown Losses 4% $32,000
- Surface Losses 3% $24,000
- 25%

Distribution System Losses
- Insulation Losses 7% $56,000
- Steam Leaks 6% $48,000
- Blowing Traps 5% $40,000
- Flash Losses 11% $88,000
- Return Losses 9% $72,000
- 38% $304,000

Combined Losses 63% $504,000
System Efficiency 37% $296,000
Steam System Connections-Example

- Operator competence and associated training

<table>
<thead>
<tr>
<th>Competency</th>
<th>Training</th>
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<tbody>
<tr>
<td>General knowledge of boiler operation</td>
<td>Complete 2 day-Boiler Operation, Maintenance &amp; Safety course</td>
</tr>
<tr>
<td>Ability to understand and follow startup and shutdown procedures</td>
<td>1 week on-the-job training with experienced boiler operator</td>
</tr>
<tr>
<td>Ability to test boiler water and make necessary adjustments</td>
<td>1 day on-site training with water treatment chemical tech rep</td>
</tr>
<tr>
<td>Ability to test burner performance, calculate combustion efficiency and</td>
<td>Complete 1 day-Combustion Analysis and Fuel Efficiency course and pass</td>
</tr>
<tr>
<td>adjust combustion controls as needed</td>
<td>HVAC Excellence Combustion Analysis exam</td>
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Steam System Connections-Example

- **Procurement of services, products and equipment associated with steam system - Procedures**
  
  - Notify potential suppliers of steam system equipment and products that evaluation of their offerings are partly dependent upon energy performance (e.g. includes products like water treatment chemicals or steam traps and equipment like deaerators, feed pumps or stack economizers).

  - Assess energy use over lifetime: Inform purchasing that large capital items (> $20,000) will have a lifecycle cost evaluation prepared that includes at a minimum initial cost, annual maintenance, energy cost savings and salvage cost based on expected lifetime.
## Steam System Connections-Example

<table>
<thead>
<tr>
<th>Operating control topic</th>
<th>Control method</th>
</tr>
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<tbody>
<tr>
<td>General boiler operation</td>
<td>Attend boiler operator training course</td>
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<tr>
<td>Boiler startup/shutdown</td>
<td>On-the-job training on how to follow procedures</td>
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<tr>
<td>Emergency conditions</td>
<td>Safety covered in operator training course</td>
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<table>
<thead>
<tr>
<th>Maintenance control topic</th>
<th>Control method</th>
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<tr>
<td>Steam trap inspection</td>
<td>Traps are tested monthly with ultrasonic meter and losses tracked. Trap replaced or repaired when loss &gt;$2.5K/yr</td>
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<tr>
<td>Boiler tune-up</td>
<td>Boiler performance monitored weekly and tune-up is completed when efficiency decreases by 3%</td>
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<tr>
<td>Steam leak inspection/repair</td>
<td>Boiler operating procedure requires weekly inspection and write-up of visible leaks by operators that are then assigned to maintenance for repair</td>
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Steam System Connections-Example

Monitoring & measurement practice

- Maintenance procedure: monthly test of exhaust stack excess oxygen and temperature to determine combustion efficiency
- Record feedwater flow rate from water meter daily
- Measure feedwater and boiler water solids concentration daily, use ratio of concentrations to calculate blowdown rate
- Record natural gas flow rate daily from gas meter
- Boiler performance determination:
  1. Steam production - Subtract blowdown rate from feedwater rate
  2. Calculate energy in steam – enthalpy difference of steam and feedwater
  3. Boiler efficiency - steam energy divided by fuel input
  4. Compare calculated boiler efficiency with measured combustion efficiency
Barriers associated with SEUs

- Incomplete equipment lists and inadequate consumption data for energy uses
- Relying on part of the organization when determining significance criteria
- Deciding that everything is significant – instead of keeping it manageable!
- Ignoring required connections when developing SEU methodology
- Lack of metering to adequately monitor and measure SEU performance
See you in 45 minutes!
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Implementation & Operation

- Competence, training and awareness
- Documentation
- Operational control
  - Key Area
  - Operation and Maintenance
  - Service Contractors
  - Training
- Communication
- Design
  - Energy Efficient Design (EED)
- Purchasing energy, services, goods
- Action Plan
Connections to Significance

Significant energy uses

Operational control

- Competence, training and awareness
- Procurement
- Objectives, targets and action plan
- Monitoring, measurement and analysis
What is Required by the EnMS?

- Determine and plan operations associated with significant energy uses
- Set criteria for operation and maintenance of significant energy uses
- Communicate to the appropriate personnel
- Operate and maintain according to criteria - handle significant deviations

NOTE: May include energy performance consideration in contingency planning
Operational Control: A critical element of the EnMS for energy savings

Steps in achieving effective operational control:

1. Determine and establish maintenance and operational criteria
2. Communicate operational controls
3. Operate according to the criteria

Leads to,

SIGNIFICANT ENERGY SAVINGS & BENEFITS
WITHOUT CAPITAL EXPENDITURE!
Developing Criteria

Sources of Criteria

- Manufacturer’s recommendations
- System operational manuals, including automated controls
- Service personnel suggested operating settings
- Service personnel suggested maintenance practices
- Internal expert’s suggestions
- Guidance from energy system experts
- Benchmarking performance of similar equipment
- Past issues or problems
Operational Criteria

➤ Operating criteria
  • Temperature
  • Pressure
  • Residence time
  • Humidity
  • Control schemes
  • Others
The primary purpose of maintenance has traditionally been to maintain reliability and availability.

If equipment is properly maintained it is more likely to be energy efficient also.

Reactive maintenance will undoubtedly waste energy.

The cost of the energy will often be more than the cost of the maintenance (also a different budget!)

All significant energy users need to be maintained correctly.

Applies equally to external service contracts as internal maintenance staff.
Maintenance options

- Preventive maintenance
- Predictive maintenance
- Reliability centred maintenance (RCM)
- Overall equipment effectiveness (OEE)
- Total productive maintenance (TPM)

Note: reactive maintenance may be appropriate for items that are relatively unimportant in terms of reliability and energy use
Maintenance Criteria & Factors

- **Maintenance criteria**
  - Filters
  - Lubrication
  - Tune-ups, adjustments

- **Maintenance factors**
  - Operating schedules
  - Inspection methods and intervals
  - Start up & shut down frequency
  - Severity of service
Document Criteria

- Use the tab in the tools
- Include operating limits for the criteria where appropriate
Communication of Criteria

- On-the-job training
- Work instructions or operating procedures
- Classroom training
- Posted list of specified settings
- Logbooks
Implementation of Criteria = Controls

- **Procedures Based**
  - Procedures or work instructions
  - Equipment logbooks
  - PM Schedule

- **Technology Based**
  - Control systems
  - Alarm/alert systems
  - Computer automated activities
  - Preventive maintenance system

- **Training Based**
  - Maintenance training
  - Operations training
  - Contractor training

- **May already have many operational controls in place!**
Investigation of Significant Deviations

- How will significant deviations be handled?
- Will significant deviations be placed into the corrective action system?
- What methods will be employed during the investigation?
  - 5 whys
  - IS/IS NOT
  - Fishbone
  - Other root cause analysis methods
- What records will be kept?
Identification of Significant Deviations

- What will be considered a significant deviation?
  - Trend identified
  - Outside of control limits
  - Higher or lower than designated value
  - Percentage different from what is expected

- Find out what happened
- Take appropriate action
- Keep a record

You determine what will be considered a significant deviation!
Analysis of Significant Deviations

What type of data analysis methods will be used?
- Absolute analysis
- Control limit analysis
- Trend analysis
- Benchmarking
Operating Controls-Best Practice

- Clearly define requirements
- Conduct training for operations and maintenance
- Keep documentation current
- Remember, even technology-based controls require some training and documented procedures
- Ensure recommended practices are being followed & significant deviations handled
Contingency, Emergency or Disaster Situations

- May consider operational control requirements for energy performance during contingency situations
- To plan contingent operational control, first define contingency to isolate potential effect on SEU
- After contingency is defined, determine necessary changes to criteria and establish controls
Contingency Situation Example

- Dual-fuel boiler operating normally on interruptible natural gas. An extended cold-snap will necessitate operation on #2 fuel oil during a gas interruption. What operational changes are anticipated?

- What happens if there is an electrical power interruption?
  - Short outage
  - Long outage
Connections to Significance

- **Operational control**
- Competence, training, and awareness
- Procurement
- Objectives, targets, and action plan
- Significant energy uses
- Monitoring, measurement, and analysis
Operational Controls & Monitoring and Measuring

Monitor & Measure
- Monitor = passive data acquisition: utility meters, panel meters
- Measure = active data collection: sub-meters, data loggers

Energy Performance
- Use M&M data to determine SEU performance
- Calculate efficiency, specific energy or input per unit output

Operational Control
- Is SEU energy performance as expected?
- Are controls working?
- How can they be improved?
Barriers to effective operational controls

- Implementing controls that are not easy to use, understand or communicate (controls not user-friendly)
- Forgetting to include maintenance criteria in addition to operating criteria
- Infrequent communication of operational controls
- Not checking control effectiveness regularly
- Failing to improve ineffective controls
Promotes efficient, uninterrupted operation of critical equipment

Criteria for efficient operation can help identify actions that will support targets and objectives

Implementation of controls or refinement of existing controls can result in significant savings with no capital cost

Control energy spend by controlling highest cost uses

Improves uniformity of process

Provides continuity of processes during personnel changes

Allows operators to help with energy savings
Exercise

Determine what operational and maintenance criteria it takes to run and maintain one of your SEUs in an efficient manner, and record these criteria on UNIDO tools.
See you in 15 minutes!
# Module 2 – Operations – Day 1

<table>
<thead>
<tr>
<th>Topic</th>
<th>Duration (mins)</th>
<th>Exercise (mins)</th>
<th>Break duration</th>
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Implementation & Operation

- Competence, training and awareness
- Documentation
- Operational control
  - Key Area
  - Operation and Maintenance
  - Service Contractors
  - Training
- Communication
- Design
  - Energy Efficient Design (EED)
- **Purchasing energy, services, goods**
- Action Plan
Procurement

- Can have a significant impact on your energy performance
- You need to be able to assess the energy performance and impact of items that you purchase
- Inform all vendors that you have an EnMS that requires energy impact to be assessed as appropriate
- Need to move towards Life Cycle Costing (LCC)
Procurement of Energy Services, Products and Equipment

- If purchases affect significant energy use (singular) notify suppliers evaluation partly based on energy performance
- Designate how energy use over the lifetime of the product, equipment or service will be assessed for purchases that have significant impact on energy performance
  - Significant energy use
  - Objectives and targets
  - Past improvement efforts
  - Maintenance of energy system
Purchasing goods

Many purchased items can impact energy performance

- Air compressors, motors, boilers, pumps, etc.
- IT equipment, PCs, printers, photocopiers, etc.
- Light bulbs
- Maintenance materials, insulation, gaskets, bearings, lubricants, etc.

Establish criteria for assessing energy use, consumption and efficiency

Develop purchasing specifications for these items

Need an analysis that incorporate life cycle costing
Purchasing services

- Energy service providers who will affect energy performance need to be evaluated
  - Maintenance service contractors for SEUs
  - Project engineers/managers/architects
  - Energy consultants
- Informed procurement partly based on energy performance
- Develop criteria for assessment
- Major component of assessment is competency
  - Education
  - Training
  - Skills
  - Experience of previous similar services
Purchasing services

- Any service provider who will affect your significant energy uses needs to be competent

- They include:
  - Maintenance service contractors for SEUs
  - Project engineers/managers
  - Architects
  - Energy consultants

- You need to be able to judge competence
  - Education
  - Experience of previous similar services
  - References
  - Curriculum vitae (CV) or resume
Supplier Notification

- Notify suppliers that evaluation will be partially based on energy performance
  - Letter
  - PO
  - Specification
  - Training
  - Supplier open house
  - Email
  - Service letter agreements
What about purchasing energy saving technologies?

- There are many vendors of energy saving technologies
- You need to be able to judge real saving potential from what the sales person says.
- Try a sample as a test
- How do you verify savings?
- Nobody admits to buying the wrong thing
- Some good technologies are only good in the right application, e.g. variable speed drives
Life Cycle Analysis

- Upfront expense
- Incremental cost
- Energy cost
- Maintenance cost
- Expected lifetime
- Disposal cost/Salvage value
Life Cycle Costing

- Demonstrate using the tool
- Very important concept
- Useful in real EnMS
What if Procurement is a Corporate Function?

- Is the purchase of the service, product, or equipment related to a significant energy use?
  - Inform corporate that energy performance is important in decision
  - Request energy be a criteria in evaluation
  - Request that corporate notify suppliers that energy performance will be taken into consideration
Communication Ideas

If procurement is a corporate function:

- Is there information that the facility can provide corporate purchasing to make their buying decisions more effective, for equipment or energy supply?

- Is there energy supply price signal information that corporate can provide to the facility that might impact operational decisions?
Procurement of Energy Supply

- Defined and documented energy purchasing specifications
Purchasing energy

- Increasingly complex area with competition
- Need to know who are the potential suppliers
- Need understanding of available tariffs
- Need understanding of specification of energy requirements
- If significant energy savings are achieved through EE this may affect best tariff structure
- Need each supplier to quote for the same thing and same basis, need to be able to compare quotes
Energy Supply Specifications

➢ Quality
  • Moisture
  • Composition
  • Energy Content
  • Voltage
  • Amperage
  • Power Factor

➢ Quantity
  • Amount supplied
  • Delivery period
  • Interruptible?

➢ Reliability
  • Allowable variation in quality
  • Allowable variation in supply

➢ Cost Factors
  • Cost per unit
  • Cost for non-interruption
  • Cost for demand
  • Cost for delivery
Exercise

Consider the procurement policies and procedures in your organization. Determine the gaps in your procurement procedures and the actions needed to fill those gaps.

This exercise is the start of the process. You will need to progress this over the coming months and years.
## Module 2 – Operations – Day 1

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- Action Plan
Competence, Training and Awareness

- Ensure those related to significant energy uses are competent.
- Identify training needs related to the control of its SEUs.
- Provide training or take other actions.
- Maintain records of training.
Three Cogs

- Awareness
- Training
- Competence
Competence

- Education, training, skills, or experience
- Records
- How am I qualified to do this job?
- Related to significant energy uses
# Competence Process

## Competence

<table>
<thead>
<tr>
<th>Determine Categories of persons</th>
<th>Determine education, skills, experience, skill combination for categories</th>
<th>Review persons vs competence and determine training needs</th>
</tr>
</thead>
</table>

The GAP

Competency process

Competent

Training Process
Training Needs

• Competency defines what is needed
• Training needs define what is missing or has changed
• Records of the training provided are required

Other Options
✓ Reassign to another activity
✓ Provide additional training
✓ Assign a mentor
✓ Increase the training opportunities
✓ Remove from the situation
Training methods

- Classroom training
- On-the-Job training
- Certification program
- Work with a mentor
- Work with a supplier or contractor
- Web-based training
- Time in a job
# Training Plan

## Training

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<thead>
<tr>
<th>Employee ID</th>
<th>Name</th>
<th>Job Title</th>
<th>Department</th>
<th>Category</th>
<th>Introduction to EnMS</th>
<th>EnPIs</th>
<th>SEU 1</th>
<th>SEU 2</th>
<th>SEU 3</th>
<th>Energy for Influencers</th>
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Awareness

The organization shall ensure that persons working for or on its behalf are aware of:

- Energy policy
  - Importance
- Procedures
- Roles, responsibilities and authorities
- Benefits of improved energy performance
- Impact actual or potential, respect to energy use and consumption,
- How their actions contribute to achievement of energy objectives and targets
- Potential consequences of departure from procedures
Awareness – Behaviour Change – Social Norms

- Safety Belts in Cars
- Smoking in public places
- Smoking while Pregnant
- Seat belts in cars
- Safety glasses
- Etc
- Etc
- Etc
- Energy Waste?
Benefits

- Increased energy awareness
- Better decision making capability of staff
- Improved energy performance
- Improved qualifications of staff
- Increased understanding of processes and energy relationships
Connections

- Policy
- Competence, Training, Awareness
- Significant Energy Uses
- Operational Control
- Management representative
Documents & Records

Documents
- Competency requirements
- Training needs

Records
- Competency records
- Training records
EXERCISE

- Consider one of the SEUs that you have identified and the operational criteria required to operate the SEU in an efficient manner.
- List those personnel who operate and maintain the SEU (don’t forget external contractors).
- Review with the team different ideas on types of competencies that may be necessary and examples of how this is currently managed.
- Update the training tab on the tools spreadsheet.