

Exhaust Air Energy Recovery: User Guide

Introduction

In systems with exhaust air energy recovery, some of the energy from the exhaust air stream is used to precondition the incoming fresh air stream. A variety of devices can be used to mediate the energy exchange. Some devices transfer sensible heat only (e.g. heat pipe, sensible plate, sensible wheel, glycol run-around systems), while some transfer both heat and moisture between air streams (e.g. enthalpy plate, enthalpy wheel).

Good applications of exhaust air energy recovery include systems with large ventilation air requirements in hot or cold climates. Systems that include moisture recovery are beneficial when outdoor humidity levels are very different from controlled indoor conditions.

In addition to producing energy savings, exhaust air energy recovery may allow downsizing of heating and cooling systems due to reduced ventilation loads at design conditions.

The Exhaust Air Energy Recovery Custom Express spreadsheet calculates the annual energy savings associated with exhaust air energy recovery systems, and produces a preview of the available incentive. (Incentive amounts are subject to approval by National Grid.)

Applicability

This spreadsheet is designed to be applied to a wide range of situations, including:

- New construction (“D2”) and retrofit (“E1”) applications
- Heat recovery devices of the following types: sensible wheel, sensible plate, enthalpy wheel, enthalpy plate, heat pipe, glycol run-around
- Systems with constant supply airflow and variable air volume systems

This tool must not be used in the following situations:

- If the proposed energy recovery system does not exceed the requirements of the applicable building code. This condition applies to new construction projects only; no energy savings can be associated with a new system which does not exceed code requirements. See page 2 for information on entering the applicable code baseline.
- If the proposed energy recovery is not *exhaust* air energy recovery, e.g. the tool cannot be used to calculate savings due to wrap-around precool/reheat (“desaturation”) cooling coils
- If the proposed system is to be equipped with demand-controlled ventilation in addition to exhaust heat recovery
- If the performance of the installed heat recovery equipment is expected to be significantly degraded by dirt or other site conditions

Compatibility

The spreadsheet is compatible with MS Excel 2003 and later versions.

Questions?

Please contact Dinesh Patel at National Grid (dinesh.patel@nationalgrid.com) with any questions on the applicability or use of this spreadsheet tool. Contact the facility owner’s representative, design engineer, equipment vendor, or facility manager for assistance in obtaining the information requested in the spreadsheet.

Version Information

This user guide applies to V2 of the ERV Custom Express tool, with code baseline selection activated.

Usage instructions

Open the spreadsheet (ERV Custom Express.xls) in MS Excel. Work through the spreadsheet's tabs in sequence, starting with the Instructions tab.

Instructions tab:

This tab contains a brief version of the instructions contained in this user guide. Please pay particular attention to the first instruction: **you must enable macros to allow the sheet to work.**

Basic Info tab:

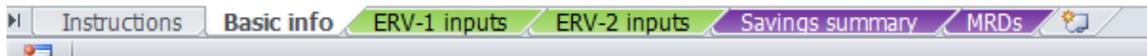
Enter **all** requested information on the Basic Info tab. The calculation will not function properly if certain fields are not completed.

The screenshot shows the 'National Grid ERV Custom Express Tool' form. It contains several input fields: Date, Application #, NGrid contact, Facility name, Facility street address, State (with a red note '(must be completed)'), Weather location (with a note '(pick closest match)'), Number of non-identical ERVs (with a note '(for more than 5 ERVs, continue on a second spreadsheet)'), New AHUs or retrofit ERVs? (with a note '(use separate spreadsheets for different types of installation)'), Applicable code baseline (with a note '(Please refer to user guide for details)'), Customer contact, Customer phone #, Customer email address, Type of facility, and a large Notes text area. A red warning message reads: 'Please make sure to complete the fields below before proceeding:'.

Notes on specific fields:

- **Weather location:** choose from the dropdown list. Choose the location whose climate most closely matches the climate at the facility's location. The available locations are: Boston, Worcester, Providence, New York City, Albany, Buffalo, Syracuse, and Watertown, NY.
- **Number of non-identical ERVs:** enter the number of unique systems you wish to include in the application. Identical systems can be entered using a multiplier, so you don't have to enter the same data twice. For example, if your project contains four AHUs with energy recovery, of which three are identical, enter "2" in the box. An input tab will appear for each unique location system (named ERV-1 inputs, ERV-2 inputs, etc.). If you have more than 5 unique systems, please continue on a separate copy of the spreadsheet.

Note: if input tabs do not appear, please ensure that macros are enabled and that you have entered the number of non-identical systems.



- **New AHUs or retrofit:** if energy recovery is to be installed on an existing air handling system, choose "Retrofit." If the entire air handling system is new (or being replaced at the end of its life), choose "New Construction." If your project contains both retrofit and new construction portions, please use a separate copy of the spreadsheet for each.
- **Applicable code baseline** (new construction projects only): choose the applicable building code for the project. Note that the tool uses the ASHRAE 90.1 compliance path for the IECC. Requirements by state:
 - Rhode Island: select IECC 2012 starting **1 January 2014**
 - Massachusetts: select IECC 2012 starting **1 January 2015**. Note that this date differs from the MA building code changeover date of 1 July 2014.
 - New York: not applicable (National Grid does not administer the new construction program in New York state)

ERV Input Tab Layout

ERV-1 inputs
 Please complete all fields colored green. Some fields incomplete Click to clear sheet Copy all inputs from ERV- GO

1. AHU design information

Number of identical systems:

AHU/ERV name(s):

Location(s):

Design supply airflow: cfm

Supply fan hp:

Return/relief fan? hp

Variable airflow or constant volume?

Interior conditions:

Summer: °F

Winter: °F

Space temperature: °F

Space relative humidity: %

Supply air conditions:

Summer: °F

Winter: °F

Cooling coil:

Mechanical cooling?

Cooling source:

DX efficiency:

Chiller plant total efficiency: kW/ton

Heating coil:

Source:

Thermal efficiency: %

Humidification?

If yes, humidification type:

Minimum %RH setpoint: %

Thermal efficiency: %

2. Energy recovery design information

Equipment brand and model #:

New AHU or ERV retrofit? yrs Base case heat recovery:

Age of existing AHU: yrs Exception?

Type of heat recovery:

Design outside airflow: cfm

Design exhaust airflow: cfm

Sensible effectiveness: %

Latent effectiveness: %

(Effectiveness values must be based on ASHRAE conditions with balanced airflow.)

Rated OA cfm (if different from design OA cfm): If rated cfm is different from design OA cfm, pressure drop values provided below must also be at rated cfm.

Self-contained ERV or integrated fan/ERV?

Do ERV fans turn off when not recovering heat?

Heat exchanger air pressure drop: Supply: w.g.

Exhaust: w.g.

Air bypass when heat recovery is off?

Bypass air pressure drop: w.g.

If glycol run-around, pump hp: hp

Does glycol pump have VFD?

3. Usage Patterns

AHU schedule of operation:

Two seasons?

Season 2	Month	Day
Start date		
End date		

Fan Schedule Season 1		
Weekdays	System Start Time (24hr)	System Stop Time (24hr)
Weekends/holidays		

Fan Schedule Season 2		
Weekdays	System Start Time (24hr)	System Stop Time (24hr)
Weekends/holidays		

Typical hourly airflow profile

Minimum supply airflow ratio:

OPTIONAL: To override default profile shown in figure, enter percentage flow values in table below.

Hour #	AM	PM
12-1		
1-2		
2-3		
3-4		
4-5		
5-6		
6-7		
7-8		
8-9		
9-10		
10-11		
11-12		

ERV-1 supply airflow profile

4. Measure Cost

Retrofit:

Materials:

Labor:

New AHU/ERV:

Cost of unit:

Base unit cost:

Base unit shipping cost:

Base unit shipping cost for heat recovery:

Measure cost: (calculated)

Materials: \$0

Labor: \$0

5. Notes (optional):

ERV-1 Savings

		PROPOSED CASE	BASE CASE (if applicable)
Calculate ERV-1 Savings		Installed on: <input type="text" value="0"/>	
RECALC REQUIRED		Total electric savings (kWh): <input type="text" value="0"/>	
Some info incomplete: Fields on this tab. New/retrofit on Basic info tab. State on Basic info tab. Weather location on Basic info tab.	Peak demand savings (kW)	Dec: 0.0	Dec: 0.0
		Jan: 0.0	Jan: 0.0
		Jun: 0.0	Jun: 0.0
		Jul: 0.0	Jul: 0.0
	% on peak savings	0%	0%
	Total gas savings (therms)	0	0
	Other fuel savings (MMBtu)	0	0
Measure Cost (\$)	Materials: \$0		
	Labor: \$0		
	Program: EI		
	Measure Life (yrs): 15		
		Sensible recovery (heating):	Sensible recovery (heating):
		Latent recovery (heating):	Latent recovery (heating):
		Total heating savings:	Total heating savings:
		Humidification savings:	Humidification savings:
		Sensible recovery (cooling):	Sensible recovery (cooling):
		Latent recovery (cooling):	Latent recovery (cooling):
		Cooling electric savings:	Cooling electric savings:
		Fan/aux electric penalty:	Fan/aux electric penalty:
		Total electric savings:	Total electric savings:
		Total gas savings:	Total gas savings:
		Total other thermal savings:	Total other thermal savings:
		Demand savings:	Demand savings:
		Dec: kW	Dec: kW
		Jan: kW	Jan: kW
		Jun: kW	Jun: kW
		Jul: kW	Jul: kW
		Aug: kW	Aug: kW
		on-peak: kWh	on-peak: kWh
		off-peak: kWh	off-peak: kWh

Results preview

ERV Input tabs:

Complete all of the visible ERV Input tabs (the number of tabs displayed is equal to the number of non-identical systems specified on the Basic Info tab).

Except where a cell is marked as “optional”, enter requested information in **all** cells colored green. When all the required data has been entered, the words “Fields complete” will appear at the top of the worksheet. If required information is missing, the savings calculation will not run and the words “Some fields incomplete” will be visible.

ERV-1 inputs

Please complete all fields colored green.

Some fields incomplete

ERV-1 inputs

Please complete all fields colored green.

Fields complete

Please read all explanatory comments attached to the input cells. (Cells with comments are marked with a red triangle in the upper right corner of the cell. To read the comment, hover the mouse pointer over the cell.)

Part 1: AHU design information

In this section, you will enter design information on the air handling system on which energy recovery is to be installed. Most of the entries should be self-explanatory.

Notes on specific fields:

- **Number of identical systems:** enter the total number of systems like this one (if there are no other identical systems, enter “1”). Please remember to enter all the corresponding unit names and locations in the next two fields.
- **Interior conditions:** enter the typical summer and winter interior space conditions. If the system includes humidification, the calculation will assume that the minimum humidity setpoint is equal to the typical winter interior relative humidity.
- **Cooling efficiency:** chilled water plant or DX efficiency can be left blank if unknown. A default value will then be used by the energy savings calculation. Chilled water plant efficiency should include pumps and cooling towers (if applicable).
- **Thermal efficiency of heating or humidification:** enter the annual average thermal efficiency of the heating or humidification equipment. These fields cannot be left blank (if the system does not include humidification, the humidification thermal efficiency can be left blank).
- **Variable airflow or constant volume:** If you choose “VAV” (variable air volume), you will be able to enter the typical daily airflow pattern in **Part 3** (see below). For VAV systems, the calculation assumes that supply and return fans are equipped with variable frequency drives (VFDs) for capacity control. (It is safe to use the spreadsheet even for different types of capacity control – the associated error will be small.)
Note: for the purposes of this spreadsheet, the “VAV” category includes single-zone systems with variable airflow.

Part 2: Energy Recovery Design and Performance Information

Here you will enter information about the proposed heat recovery equipment, including system type, heat recovery effectiveness, design outside and exhaust airflow, and air pressure drop.

- As noted on the spreadsheet, the heat recovery effectiveness values must be at AHRI rating conditions with balanced (i.e. equal) outside air and exhaust airflows. Please refer to ANSI/AHRI Standard 1060 for details on the rating procedure. Rated performance information (including effectiveness and air pressure drop) is available for many energy recovery ventilation units on the AHRI website:

<http://www.ahridirectory.org/ahridirectory/pages/erv/defaultSearch.aspx>

- If the proposed equipment appears on the AHRI, please include a copy of the AHRI performance data with the custom express spreadsheet when you send the completed sheet to National Grid.
- If the proposed equipment does not appear on the AHRI website, please provide a manufacturer’s cutsheet showing all requested performance data **at AHRI conditions with balanced airflow** (outside airflow and exhaust airflow both equal to the design outside airflow for the system).
- If the airflow at which the energy recovery device is rated is not the same as the design outside airflow of the proposed system, enter the value of the rated airflow in the “Rated OA cfm” cell. If rated and design airflows are the same, leave the box blank.

Rated OA cfm (if different from design OA cfm): cfm

Important: if you enter a value in the “Rated OA cfm” box, **all** pressure drop information must be entered for the **rated** airflow.

- Important note about heat recovery effectiveness: you must enter the **effectiveness** as defined by AHRI and ASHRAE (i.e. defined in terms of the amount of heat recovered as a fraction of the maximum recoverable heat at rating conditions), **not** any other performance measure (e.g. “efficiency”) of the proposed heat recovery system.

- System type definitions:

Self-contained ERV or integrated in AHU?

- In an **integrated system**, the main AHU supply and return/relief fans are used to draw air through the heat recovery device. This can be either a new construction or retrofit application.
- A **self-contained ERV** contains separate dedicated fans to draw outside air and exhaust air through the heat recovery device (this is typically a retrofit application, in which an ERV module is added to an existing air handler).
- Air bypass question: please enter “Yes” if the outside and exhaust air streams do not pass through the heat recovery device when the system is not recovering heat (e.g. when the system is in airside economizer mode). You will then be asked to enter the air pressure drop of the bypass path, which is preferably less than the air pressure drop through the heat recovery device.

- Code-minimum heat recovery requirement: if the system is required by the applicable code to include exhaust heat recovery, this will be indicated as shown at right. In this case, the proposed system will be compared to a base case system containing an enthalpy plate heat exchanger with 50% total effectiveness. If an *exception* to the code requirement applies to the proposed system, please select “Yes” in the relevant box; the system will then be compared to a base case with no exhaust heat recovery. Use of any exception **must** be explained in the “Notes” field and justified to National Grid’s satisfaction.

Base case heat recovery:	Yes
Exception?	<input type="text"/>

Part 3: Usage Patterns

Here you will enter the AHU’s schedule of operation and, if the unit is VAV type, the typical hourly supply airflow profile. Please note that the AHU schedule of operation could be different from the occupancy schedule of the building.

- AHU schedule of operation:

Two seasons?	
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If there are two distinct seasons of operation, e.g. if the facility is a school which closes in summer, choose “Yes.” If the AHU’s hours of operation do not change throughout the year, enter “No.”

For each season, enter the weekday and weekend/holiday AHU start and stop times (use the 24 hour clock). For example, for an AHU that operates between 8am and 8pm on weekdays, and between 9am and 1pm on weekends and holidays, the table should look as follows:

Fan Schedule Season 1		
	System Start Time (24hr)	System Stop Time (24hr)
Weekdays	8	20
Weekends/holidays	9	13

To indicate that the system remains off for the entire day, enter “0” for both start and end times.

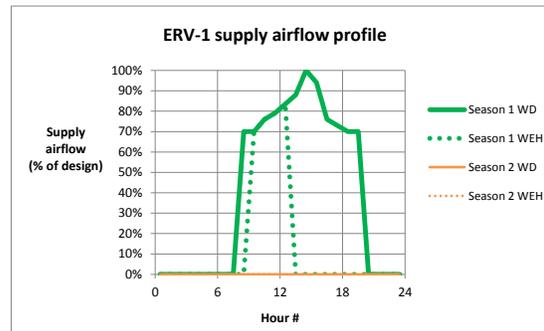
- VAV profiles:

If you chose “VAV” operation in Part 1, enter the average minimum supply airflow ratio (minimum supply airflow as a fraction of the design supply airflow):

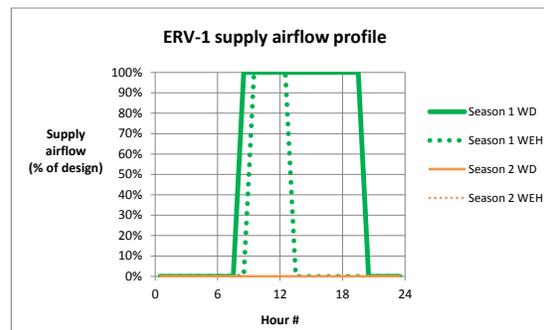
Minimum supply airflow ratio:

Please note that the “VAV” category applies to both classic multi-zone VAV systems and to single-zone systems with variable airflow.

The supply airflow profile plot will then show the default airflow profile for the day. If desired (this is optional) you can override the default flow ratio for any hour by entering a value in the table provided. If you are not sure what to enter, just leave the table blank to use the default profile. A custom profile could be useful for e.g. a lab system which operates at design flow (100%) during the day and at 50% flow during nights and weekends.



For a **constant volume** system, the plot is still a useful check of the start and stop times entered in the usage table.



Part 4: Measure Cost

Please enter cost information in the cells highlighted in green.

- **Retrofit project:** provide labor and materials costs for adding energy recovery to the existing air handling system.
- **New construction project:** in this case, the measure cost is the incremental cost associated with adding the proposed energy recovery equipment and controls to the air handling system. You must enter base and proposed case AHU costs.
 - **Proposed unit cost:** enter the cost of the proposed AHU, including heat recovery equipment and controls.
 - **Base unit cost:** the base case for the measure depends on whether the proposed system is required to include exhaust air heat recovery (see page 5 of this document for details). If the proposed system is **not** required to include exhaust heat recovery, the base cost must represent the cost of an air handling system **without heat recovery** but otherwise the same as the proposed system.

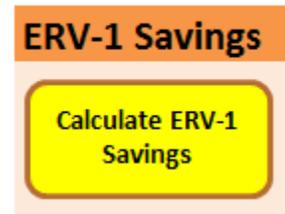
If the proposed system **is** required to include exhaust energy recovery, the base cost must represent the cost of an air handling system which **includes heat recovery with 50% effectiveness** at design conditions. The system must otherwise be the same as the proposed system.

Part 5: Notes

This section is optional. Please enter any relevant notes you wish to submit to National Grid.

Results Preview

- Once all required fields are complete on the ERV tab, the text at the top of the sheet will read “Fields complete.” If it does not, please review your inputs to ensure that all required fields have been completed.
- If further warnings appear below the “Calculate ERV-# Savings” button (located toward the bottom of the tab), please enter the requested data on the Basic info tab.
- Once “Inputs OK” appears below the Calculate ERV-# Savings button, click on the button. The results table should populate accordingly. The calculation may take a minute, depending on your computer’s capabilities.
- A summary of the savings associated with the heat recovery system will then appear at the bottom of the sheet.
- For new construction systems which require code baseline heat recovery (see **Part 4** above), the savings associated with the base case (relative to no heat recovery) will also be shown. The summary table on the left then shows the difference between base and proposed cases, i.e. the measure savings.



Other ERV Input tabs:

Enter information in the same way on all the other ERV tabs. If many of the inputs are the same, all inputs can be copied from another ERV sheet using the button at the top right of the sheet. All entries can also be cleared if desired.

[Click to clear sheet](#)

Copy all inputs from ERV- [GO](#)

Savings Summary Tab:

Once all ERV Input tabs are complete, a summary of the savings is available on the “Savings Summary” tab.

If any “Calculation Status” field indicates that recalculation is required, click on the button below the table:

[Click to calculate Savings for all ERVs](#)

The Savings Summary tab shows the savings associated with each system, multiplied by the number of identical systems of each type. A preview of the available incentive is shown for each group of systems, along with the total savings and costs for all systems. Incentive amounts are subject to approval by National Grid.

If any of the Input status fields does not show “Inputs OK,” or if any warnings appear below the table, please address the issues and then recalculate the savings before forwarding the spreadsheet to National Grid.

MRDs tab:

The minimum requirements document (MRD) for the project will be generated automatically. It can be previewed on the “MRDs” tab. This page can be printed to collect required signatures, if requested by your National Grid representative.

Submitting to National Grid

Please save and forward the completed spreadsheet to your National Grid representative, along with the AHRI certification or other required documentation. The spreadsheet file size will probably remain under 10 MB, which should not cause a problem for most email services. If the file is too large to email, or if you are sending multiple files at the same time, please compress it/them and send the zip file instead.

Please contact National Grid with any questions or concerns.

Measure cost and annual savings summary

		ERV-1	Total
Installed on:		AHU-1	All
# of identical systems:		1	--
Total electric savings (kWh)		-5,256	-5,256
Peak demand savings (kW)	Dec	-1.3	-1.3
	Jan	-1.3	-1.3
	Jun	0.7	0.7
	Jul	2.0	2.0
Aug		2.0	2.0
% on-peak savings		31%	31%
Total gas savings (therms)		8,168	8,168
Other fuel savings (MMBtu)		0	0
Measure Cost (\$)	Materials	20,000	20,000
	Labor	5,000	5,000
Program		EI	EI
Measure Code		ERV	ERV
Measure Life (yrs)		15	15
Gas Incentive (\$)		12,500	12,500
Simple Payback incl. Incentive (yrs)		1.3	1.3
Calculation Status:		Calc OK	Calc OK
Input status:		Inputs OK	Inputs OK

[Click to calculate Savings for all ERVs](#)