Code Amendment Proposal Form

For public amendments proposed to the 2021 editions of the International Codes

DENVER COMMUNITY PLANNING & DEVELOPMENT

Instructions: Upload this form and all accompanying documentation. If you are submitting your proposal on a separate sheet, make sure it includes all information requested below.

All proposals must be received by **July 23, 2021**.

CONTACT INFORMATION

Name: **Michael Fulton, PE** **Date:** **Revised 2/14/22**

Phone: **720-934-8273** **E-mail:** **mfulton@westernmechanicalsolutions.com**

Organization or Representing Self: **Western Mechanical Solutions, LLC.**

By signing below, I hereby grant and assign to City and County of Denver all rights in copyright I may have in any authorship contributions I make to City and County of Denver in connection with this proposal. I understand that I will have no rights in any City and County of Denver publications that use such contributions in the form submitted by me or another similar form and certify that such contributions are not protected by the copyright of any other person or entity.

Signature:

AMENDMENT PROPOSAL

Please use a separate form for each proposal.

1) Code(s) associated with this proposal. Please use acronym: **IECC**
If you submitted a separate coordination change to another code, please indicate which code: ____________

Acronym	Code Name	Acronym	Code Name
DBC-AP	Denver Building Code–Administrative Provisions	**IFC**	International Fire Code
DBC-*xxxx*	Denver Building Code–*xxxx (code)* amendments (e.g., DBC-IBC, DBC-IEBC)	**IFGC**	International Fuel Gas Code
		IRC	International Residential Code
IBC	International Building Code	**IMC**	International Mechanical Code
IEBC	International Existing Building Code	**IPC**	International Plumbing Code
IECC	International Energy Conservation Code	**DGC**	Denver Green Code

2) Please check here if a separate graphic file is provided: ☐
Graphics may also be embedded within your proposal below.

3) Use this template to submit your proposal or attach a separate file, but please include all items requested below in your proposal. The only formatting needed is **BOLDING**, ~~STRIKEOUT~~ AND UNDERLINING. Please do not provide additional formatting such as tabs, columns, etc., as this will be done by CPD.

Code Sections/Tables/Figures Proposed for Revision:

Modified Section C403.7.4.2, Modified Table 403.7.4.2(1) & (2), modified exception #8 and added exception 12.

Note: If the proposal is for a new section, indicate (new).

Proposal:

C403.7.4.2 Spaces other than nontransient dwelling units.

Revise as follows: Where the ~~supply~~ outside or exhaust airflow rate of a ~~fan~~ system serving a space other than a nontransient dwelling unit exceeds the values specified in modified Tables C403.7.4.2(1) and C403.7.4.2(2), the system shall include an energy recovery system.

The energy recovery system shall provide an enthalpy recovery ratio (ERR) of not less than ~~50~~ 60 percent at balanced airflow conditions. At non balanced airflow conditions, minimum ERR shall equal 60% ERR x (Exhaust cfm / outside cfm), to a maximum of 72% when Exhaust CFM ≥ 1.2 x Outside Air CFM. Where an air economizer is required, the energy recovery system shall include ~~a~~ bypasses on outside and exhaust air or controls that permit operation of the economizer as required by Section C403.5. ~~Maximum heat exchanger pressure drop is 0.6 in. w.g. at sea level and standard density without requiring bypass dampers.~~ Energy recovery devices shall not exceed 1.1" w.g. S.L. at design airflows and shall not exceed 0.6" w.g. S.L. in 100% OA & EA economizer mode with bypass dampers open. Supply and exhaust fan static efficiency must meet Table C403.8.1(1) and C403.8.3.

Revise Tables as follows:

TABLE C403.7.4.2(1)
ENERGY RECOVERY REQUIREMENT
(Ventilation systems operating less than 8,000 hours per year)

Climate Zone	Percent(%) Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design ~~Supply Fan~~ Outside or Exhaust Airflow Rate (CFM)							
5B Values Were	~~NR~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~	~~NR~~
5B Outside	NR	NR	NR	NR	6,000	5,500	5,000	4,000
5B Exhaust	NR	NR	NR	NR	4,500	4,125	3,750	3,000

For SI: 1 CFM = 0.4719 L/s.
NR = Not Required.
Requirements are based on a 10 year payback, 6 am to 6 pm 5 days a week

TABLE C403.7.4.2(2)
ENERGY RECOVERY REQUIREMENT
(Ventilation systems operating more ~~not less~~ than 8,000 hours per year)

Climate Zone	Percent(%) Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design ~~Supply Fan~~ Outside or Exhaust Airflow Rate (CFM)							
5B Values Were	~~≥2,500~~	~~≥2,000~~	~~≥1,000~~	~~≥500~~	~~≥140~~	~~≥120~~	~~≥100~~	~~≥80~~
5B Outside	500	400	300	200	84	84	80	80
5B Exhaust	1,500	1,200	900	600	252	252	240	240

For SI: 1 CFM = 0.4719 L/s.
NR = Not Required.
Requirments are based on current code

Exception.

6. Modify as follows: Enthalpy recovery ratio requirements at cooling design conditions in Climate Zone 5B however heating enthalpy recovery ratio shall be required.

8. Modify as follows: Where the largest source of air exhausted at a single location at the building exterior is less than ~~75~~ 60 percent of the design outdoor airflow rate and less than corresponding exhaust CFM in Tables C403.7.4.2(1) or (2).

12. When the exhaust flow in table C403.7.4.2(1) and (2) are exceeded, but exhaust to outside ratios are below 60%, an outside air bypass may be employed with a control method to ensure the exhaust to outside air ratio stays at or above 60% Outside air heat wheel CFM and bypass CFM shall be clearly noted on the plans.

13. Projects where exhaust air is rated as class 3 or class 4 (where not prohibited by IMC 5.4), will require an enthalpy recovery ratio of not less than 50% at 100% exhaust to outside air ratio.

Note: Show the proposal using ~~strikeout~~, underline format. At the start of each section, give one of the following instructions:

- Revise as follows:
- Add new text as follows:
- Delete and substitute as follows:
- Delete without substitution:

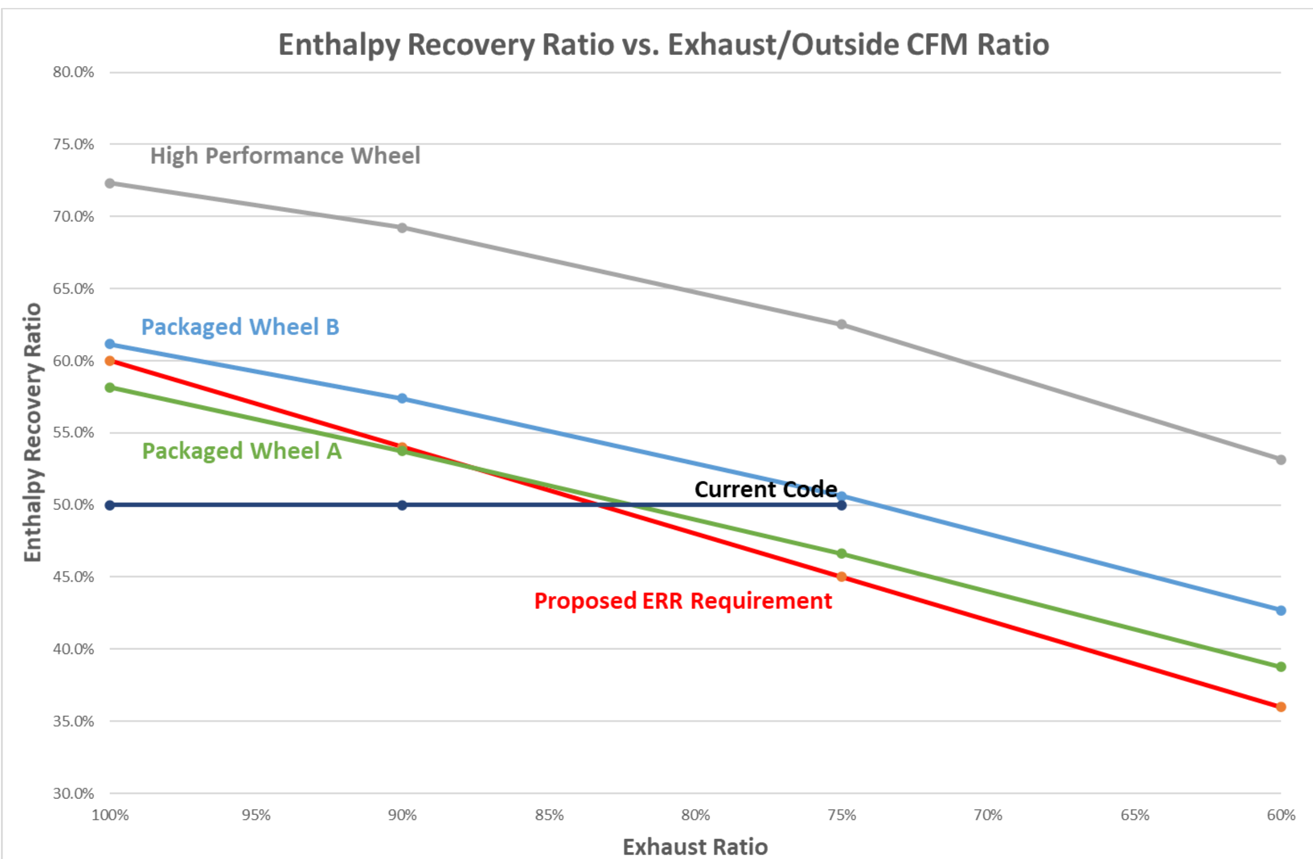
Supporting Information:

Purpose: Recovering ventilation energy is among the most efficient ways of saving energy in the industry. Boasting heating COP's over 100, energy recovery is incredibly efficient. As we transition to electric heating baselines, the payback period for heat recovery significantly reduces as electricity is more expensive than natural gas per unit of energy. Additionally, the implementation of heat recovery systems allows for the reduction of building heating and cooling system sizes, further decreasing the payback period!

Reasons: Energy recovery is economical in Denver with good paybacks. Code now requires 60% winter enthalpy recovery ratios (ERR) for Non Transient dwelling units - C403.7.4.1. The revised table proposed is based on 11.7 year paybacks (values ASHRAE 90.1 uses) with a 75% E/OR (Exhaust to Outside Air CFM Ratio) and a gas heat baseline. Currently code only recognizes the incoming air, but the exhaust air is rich in energy and needs to be considered as a source of heating and cooling, hence the addition of the exhaust rows. The exhaust row minimum values are based on 75% E/OR when 60% is economical for larger CFM's. Heat recovery above the proposed exhaust CFMs will be economical when combined with Exception 12 as heat recovery can be downsized.

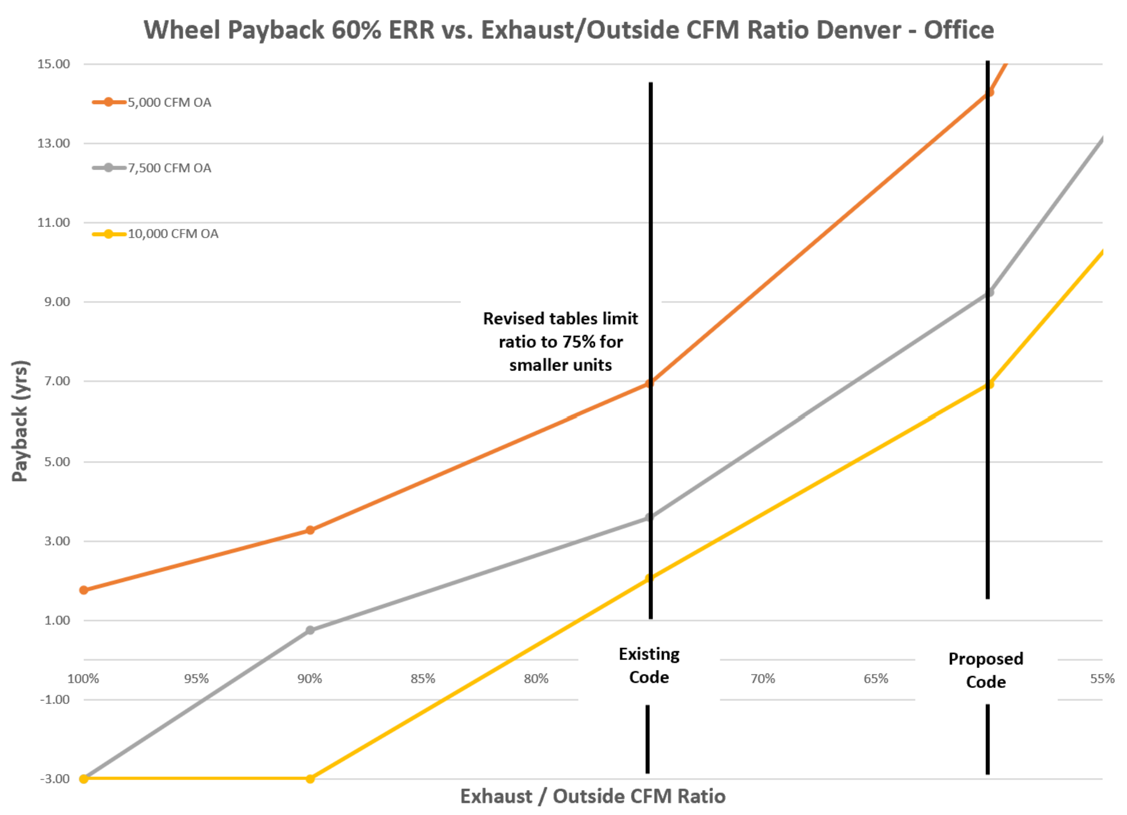
Most heat recovery (90% of the market) is accomplished with heat wheels as they are the most economical form of heat recovery. Ironically, they are usually the most efficient too. Industry standard heat wheels provide enthalpy recovery ratios (ERR) from 58 to 75% or better at 100% E/OR. However, actual ratings of heat wheels (see graph below) show the ERR drops linearly as the exhaust ratio drops. The current code requires 50% ERR at 75% E/OR. which effectively means a 67.7% ERR at 100% E/OR so 60% ERR at 100% E/OR is achievable and economical. Therefore requiring 60% ERR at a 100% E/OR and adjusting the ERR requirement by the exhaust divided by outside ratio fixes a problem in the current code but increases the required ERR above 84% E/OR to move towards Denver's goals. Increasing the minimum heat recovery from 50% to 60% at 100% exhaust ratio therefore does not have cost implications and closes a current loophole.

The graph below shows Energy Recovery Ratio vs. Exhaust / Outside CFM ratio. Note that the revised ERR requirement formula fixes the problem where ERR is constant, regardless of E/OR, by lowering the ERR based on 60% x the ratio of exhaust CFM divided by Outside CFM. Although there is some reduction in ERR requirement below 84% E/OR, above 84% E/OR there is an increase.



The 60% energy recovery ratio values increase energy savings therefore paybacks are quicker. This has the effect of extending economical energy recovery at lower airflows. Modified values in Table 1 for outside air are based on typical Xcel Energy rates in Colorado for electric and gas heating – $ 0.70 per therm, 0.04 cents per kWh, demand per kW of $ 16.06 from October to May and $ 19.02 from June to September, 12 hours a day, 5 days a week (typical office building – low operating hours) with a 10 year payback threshold. Note an electric heat baseline in lieu of gas would result in even lower airflows being economical. Back up available on request.

The Graph below shows airflows, paybacks and Exhaust CFM/Outside Ratios. Note the immediate paybacks in some cases (anything below 0 on the Y axis. Also, the exhaust row in Table C403.7.4.2(1) is based on 75% exhaust ratio as smaller unit paybacks are lower.



Some heat recovery devices have higher pressure drop than 0.6" S.L. in 100% OA & EA Economizer mode. If this is the case, bypass dampers that open during economizer mode provide equal energy as a lower pressure drop heat recovery with no bypass dampers. This prevents parasitic losses. 0.6 in w.g. S.L. is arrived at using Table C403.8.1(2) Fan power limitation pressure drop adjustment, solving for pressure drop with 50% ERR.

TABLE C403.8.1(2)
FAN POWER LIMITATION PRESSURE DROP ADJUSTMENT

Energy recovery device, other than coil runaround loop	For each airstream, (2.2 × energy recovery effectiveness - 0.5) inch w.c.

Regarding fan efficiency, the code is not clear that both Table C403.8.1(1) and C403.8.3 need to apply to Energy Recovery.

Exception 6 is modified to clarify that although cooling is exempted in our climate zone, heating is not, the false argument is made that since cooling energy recovery isn't required, energy recovery is not required.

Exception 8 is modified to clarify that exhaust airflow above the values shown in the tables require energy recovery.

Exception 12 is added to allow partial energy recovery where the exhaust airflow volume is high enough to be economically feasible, but using the full OA CFM for sizing would result in an oversized recovery device, rendering the solution uneconomical.

Exception 13 is added to allow for lower ERR in class 3 and 4 applications (where not prohibited by IMC 5.4) with lower heat recovery technologies such as plate heat exchangers, heat pipes and run around coils. Typically, these systems are 24/7, therefore lower ERR still saves substantial energy and initial costs.

Examples are shown for Table C403.7.4.2(1) less than 8,000 hours as most applications above 8,000 hours will require energy recovery:

Example 1:

System operating less than 8,000 hours per year
SA = 12,000 CFM
OA = 6,100 CFM (50% OA/SA Ratio) Table C403.7.4.2(1) Column 5
EA = 3,700 CFM (Greater than 60% of total system OA CFM)
Therefore, energy recovery is required.
Required ERR = 60% * 3,700/6,100 = 36.4%
Conversely, if EA = 3,500 CFM, energy recovery would not be required per exception 8 as EA/OA CFM is less than the 60% threshold.

Example 2:

System operating less than 8,000 hours per year
SA = 8,000 CFM
OA = 4,000 CFM (50% OA/SA Ratio) Table C403.7.4.2(1) column 5
EA = 5,200 CFM (1,200 cfm of transfer air is coming from other systems in the building – this is greater than 4,500 exhaust requirement column 5)
Therefore, energy recovery is required.
Required ERR = 60% * 5,200/4,000 = 78%, but the maximum required is 72%.
Conversely, if EA = 4,600 CFM, and the outside air % is 40% energy recovery would not be required per Table C403.7.4.2(1) column 4, exhaust row.

Example 3:

System operating less than 8,000 hours per year
SA = 3,900 CFM
OA = 3,200 CFM (80% OA/SA Ratio) Table C403.7.4.2(1) last column
RA = 700 CFM
EA = 3,100 CFM - this is greater than 3,000 exhaust requirement last column
Therefore, energy recovery is required.
Required ERR = 60% * 3,100/3,200 = 58%
Conversely, if EA = 2,900 CFM, energy recovery would not be required per Table C403.7.4.2(1) last column as neither outside nor exhaust row threshold is met.

Example 4:

System operating less than 8,000 hours per year
SA = 20,000 CFM
OA = 11,000 CFM (55% OA/SA Ratio) Table C403.7.4.2(1) column 5
RA = 0 CFM
EA Prohibited due to class 3 or 4 = 3,000 cfm
EA = 6,000 CFM - this is greater than 4,500 exhaust requirement column 5, exhaust row.
Therefore, energy recovery is required.
Required ERR = 60% * 6,000/11,000 = 32.7%
Exemption 12 can be used to size the heat wheel for the 6,000 cfm of exhaust air and 6,000 cfm of outside air as long as the ERR is 60% * 6,000/6,000 = 60% and an OA Bypass CFM and OA Heat Wheel CFM are listed on the plans.
Conversely, if EA = 4,400 CFM, energy recovery would not be required per Table C403.7.4.2(1) column as neither exhaust row CFM nor 60% exhaust threshold from exception 8 is met.

Substantiation: Available on request – anecdotally, we were involved in a project where a MAU at 17,000 cfm was initially designed, code officials caught that heat recovery was required, the design and construction team revised the project to include energy recovery and the change was cost neutral!!

Note: This section MUST include these items:

- **Purpose**: State the purpose of the proposed amendment to physical, environmental and customary characteristics that are specific to the City and County of Denver (e.g., clarify the code; revise outdated material; substitute new or revised material for physical, environmental and customary characteristics; add new requirements to the code; delete current requirements, etc. to reflect physical, environmental and customary characteristics that are specific to the City and County of Denver)
- **Reasons**: Clearly justify the change to current code provisions, stating why the proposal is necessary to reflect physical, environmental and customary characteristics that are specific to the City and County of Denver. Proposals that add or delete requirements shall be supported by a logical explanation that clearly shows why the current code does not reflect physical, environmental and customary characteristics that are specific to the City and County of Denver and explains how such proposal will improve the code.
- **Substantiation**: Substantiate the proposed amendment based on technical information and substantiation. Substantiation provided which is reviewed and determined as not germane to the technical issues addressed in the proposed amendment shall be identified as such.
- **Bibliography**: Include a bibliography when substantiating material is associated with the amendment proposal. The proponent shall make the substantiating materials available for review.

Referenced Standards:

None

Note: List any new referenced standards that are proposed to be referenced in the code.

Impact:

Saving energy and drastically reducing carbon emissions compared to no energy recovery (in the 60 – 70% range) with a payback below 11.7 years.

Note: Discuss the impact of this proposal in this section AND indicate the impact of this amendment proposal for each of the following:

- The effect of the proposal on the cost of construction: ☒ Increase ☐ Reduce ☒ No Effect
- The effect of the proposal on the cost of design: ☐ Increase ☐ Reduce ☒ No Effect
- Is the proposal more or less restrictive than the I-codes: ☒ More ☐ Less ☐ Same

Departmental Impact: (To be filled out by CPD staff)

Note: CITY STAFF ONLY. Discuss the impact of this proposal in this section AND indicate the impact of this amendment proposal for each of the following:

- The effect of the proposal on the cost of review: ☐ Increase ☐ Reduce ☐ No Effect
- The effect of the proposal on the cost of enforcement/inspection: ☐ Increase ☐ Reduce ☐ No Effect