LESSON

Air Movement: Driving Forces

BIG IDEA(S)

The control of air movement is the main purpose of weatherization.

OBJECTIVES

Students will:

- Summarize the causes of air movement in a house
- Differentiate wind, stack and mechanical effect
- Explain how Delta P and Delta T contribute to air leakage

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WEATHERIZATION

TOPIC OF STUDY

Building Sciences

90 MINUTES

TASK LIST SUBCATEGORY

101	Explain the principles and physics of energy
109	Demonstrate strong reading comprehension for use in relevant texts and websites
801	Identify the principles of building science
802	Describe the interconnection of systems using the "House as a System" framework
804	Identify infiltration and exfiltration points
810	Use energy efficiency industry vocabulary

OVERVIEW

The control of air movement is the main purpose of weatherization. Once a house is determined to be safe and healthy, controlling air and temperature movement is the most important task. This lesson covers both pressure and temperature causes of air movement through looking at rate ($CFM_{natural}$), and common home conditions: wind, stack, and mechanical effects.

KEY TERMS

Delta P: Difference of pressure in two areas, air flowing from the high pressure to the lower. In winter, delta P is high inside and lower outside.

$CFM_{natural}$: Cubic feet per minute measure of air leakage under normal conditions

Wind Effect

Stack Effect

Mechanical Effect

Combustion Air: air that combines with fuel to produce head

Flue: a pipe that vents combustion exhaust from an appliance to outside

STANDARDS

PA/SDP

3.2.10.B3. Explain how heat energy will move from a higher temperature to a lower temperature until equilibrium is reached. Analyze the processes of **convection, conduction,** and **radiation** between objects or regions that are at different temperatures.

3.2.10.B6. Explain how behavior of matter and energy follow predictable patterns that are defined by laws

3.4.10.A2. Interpret how **systems** thinking applies logic and creativity with appropriate comprises in complex real-life problems.

3.4.10.D2. Diagnose a malfunctioning **system** and use tools, materials, and knowledge to repair it.

INSTRUCTIONAL

TEXT/REFERENCES

Energy Conservation Handbook. pp. 111 - 115

MATERIALS NEEDED

Teacher Presentation: Materials for imploding can demo (Implementation Step 1)

IMPLEMENTATION (LESSON PLAN)

1. Demonstrate what a temperature change can do to air pressure.
    a. Materials: empty soda can, bowl of ice water, kitchen forceps, heat source (hot plate, gas stove, etc.)
    b. Procedure:
        i. Hold the empty can with forceps (opening at the top) over the heat source.
        ii. When can is hot, immediately turn it over into the ice water so that the can top submerges at least an inch or so.
    c. Debrief: Ask students to explain why the can collapses. Compare the interaction of heat and pressure. (As heat in can moves to cold area (entropy, 2nd law of thermos), the air moves with it causing the side of the can to respond to the decrease in pressure.
2. As we just saw, temperatures inside and outside are the main drivers of air flow. The hot air in the can moved to the cold "outside" creating enough Delta P to collapse the can. Weatherization focuses on what happens as Delta P increases, with greater air flower through bigger passages.
3. Delta T: temp difference in two different areas, the bigger the escape routes (or in cold weather the entry routes), the faster the movement. Explain $CFM_{natural}$ and seasonal differences.
4. Rate and Replacement: Explain Leakage rate. Use the graph to show the difference in treated and non-treated window.

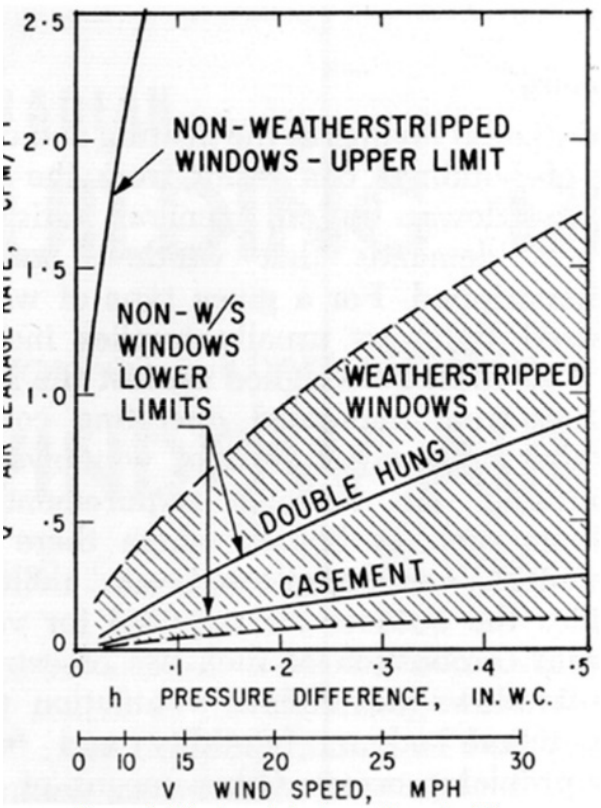

Figure 1. Window air leakage characteristics

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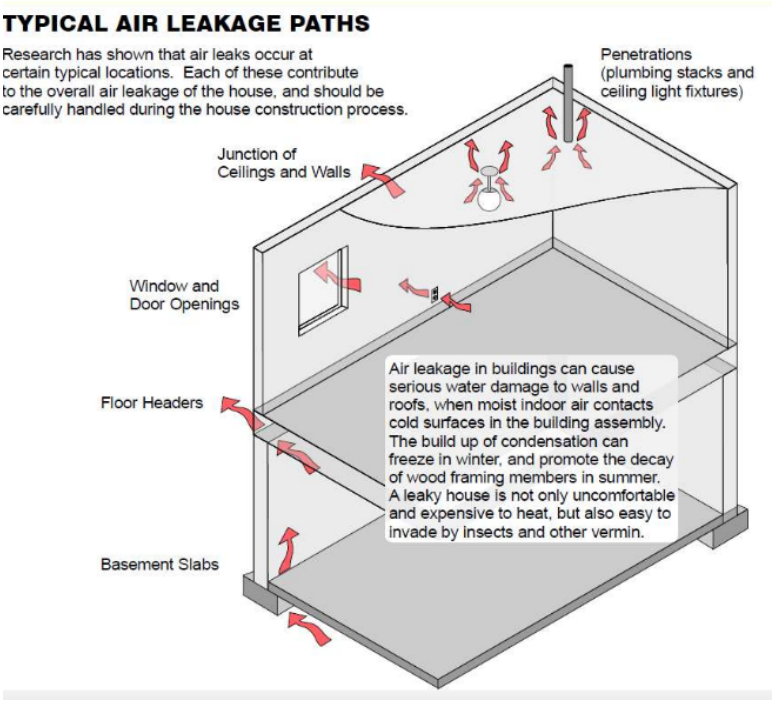
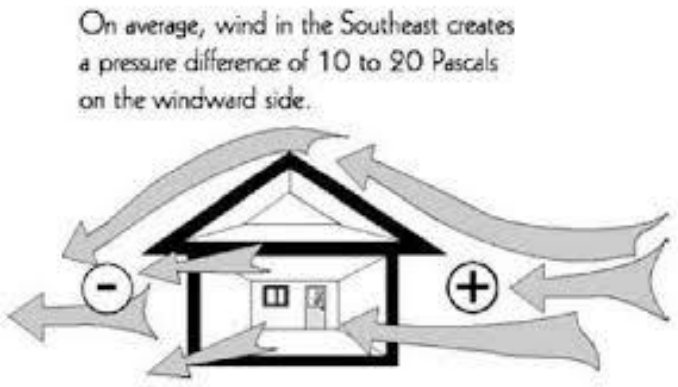
IMPLEMENTATION (LESSON PLAN) - CONTINUED

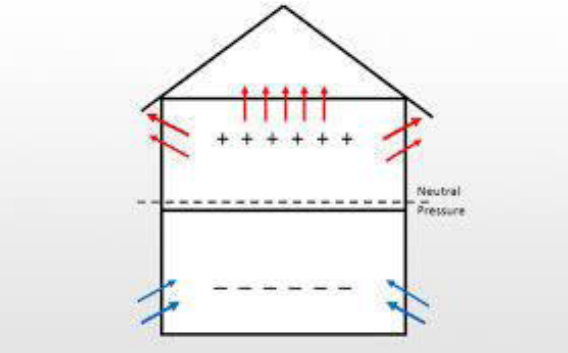
5. Direct and Indirect Air Leakage
   - Direct: vents, doors, and other intentional openings
   - Indirect: smaller, unintentional openings
   - Notice the unintentional areas.



6. Wind Effect (*Energy Conservation Handbook*, p.113)



7. Stack Effect (Review—previously presented.)



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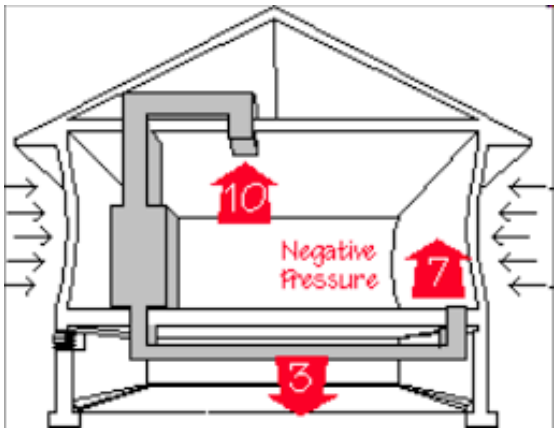
IMPLEMENTATION (LESSON PLAN) - CONTINUED

8. Mechanical Effect (*Energy Conservation Handbook*, p.118). Below is an example of a mechanical effect from a combustion appliance.
    - Unbalanced duct systems lead to pressure imbalance:



This system pulls 10 units of air from the house, sends it back to the HVAC system where it gets heated or cooled, and then puts 10 units back into the supply ducts. In this house, the supply ducts run in an unconditioned crawl space. Of the 10 units air entering the supply ducts, only 7 make it all the way back to the house.

Simple arithmetic: If you add 7 (supply air) and take away 10 (return air), you've got a negative number. In this case, the house will experience negative pressure due to the unbalanced duct leakage. That negative pressure will result in making up those 3 missing units of supply air with air that infiltrates from outside the house. It may be from the crawl space. It may be from the attached garage. It may be from the attic.

HOMEWORK

Use an internet search to find what is recommended to combat one of the effects (wind, stack, mechanical).

RESOURCES/LINKS

Another way to express the rate of air change in a house is ACHn - natural air changes per hour. This is the number of times the air is changed in a home (or space) per hour under natural conditions. This term is not unique to us energy auditors and is used by engineers to design make-up air for buildings. Each building has a target ACH it has to reach per code. For homes, ACH is a nice term for homeowners to hear and relate to, rather than CFM. One ACH means that all the air in the house is replaced one time every hour.

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