ATLANTA, GA — Amory Lovins, director of the Rocky Mountain Institute and well-known energy guru, will speak at the *Winter Meeting* of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in Atlanta, Georgia, on January 30. Lovin's topic is: "Natural Capitalism: Creating the Next Industrial Revolution." For more information on the *Winter Meeting* and the concurrently held *International Air-Conditioning, Heating, Refrigerating Exposition*, visit www.ashrae.org/MEET/winter21.htm.

PORT WASHINGTON, NY — Sales of Energy Star-certified appliances increased 31% in the first nine months of this year, according to a market research report from NPD INTELECT. Increases were posted in three out of four categories of appliances: dishwashers, room air conditioners, and washing machines. The fourth category, refrigerators, declined slightly. Energy Star dishwashers and air conditioners were both up an impressive 66% compared to the same period in 1999. The increased sales came despite the higher prices that Energy Star models command: dishwashers: 7% ($404 versus $376); air conditioners: 9% ($279 versus $257); washing machines: 129% ($869 versus $379); and refrigerators: 72% ($1,118 versus $650). For more information, contact Dora Radwick at (516) 625-6190 or dora_radwick@npd.com.

THE HAGUE, NETHERLANDS — The US economy could gain $200 billion by implementing the Kyoto Protocol on global warming. So says a new report, *Solving the Kyoto Quandary: Flexibility with No Regrets*, issued by the International Project for Sustainable Energy Paths (IPSEP). The report asserts that outdated assessments have severely distorted the US and international debate on the cost of implementing the Kyoto treaty. It claims that if energy productivity investments are put at the center of mitigation action, c change abatement can be achieved at a ne benefit for the US and other countries. Th draws on two modeling studies. One is th Energy Futures study, which was conducted by the US Department of Energy and the US Environmental Protection Agency. The other is a study called Energy Policy in the Greenhouse, conducted by IPSEP for the Dutch government. A PDF file of the report is available at www.ipsep.org. For a printed copy, contact Nancy Hayward at (650) 969-7081 or nhh@netmagic.net.

OMAHA, NE — The Omaha Chapter of Habitat for Humanity is completing construction on its 17th home using insulated concrete forms (ICF). Reward Wall Systems has donated the forms for all the Habitat ICF houses built this year. The Reward system employs lightweight foam blocks that are held together with plastic ties.

WASHINGTON, DC — The Department of Energy's Energy Information Administration (EIA) has released a new report *The Changing Structure of the Electric Power Industry 2000: An Update*, which provides a comprehensive look at the current trends that are transforming the way electric power is produced and sold. The report notes that as of July 2000, 24 states and the District of Columbia had approved the introduction of retail competition for electricity. The full report is available on EIA's Web site at: http://www.eia.doe.gov/cneaf/electricity/chg_stru_update/update2000.html.

HEARD ON THE STREET: "SUVs seem to get bigger and less fuel-efficient every year. Word has it that Detroit's next offering — The Extradition — is so large that it will only be sold to Third World dictators!"

RESEARCH AND IDEAS

How Attached Garages Poison Our Indoor Air

And What Builders Can Do About It

A new field study conducted in Anchorage, Alaska, points an incriminating finger at attached garages as a dangerous source of carbon monoxide (CO) and other indoor air pollutants. Happily, the findings also suggest some ways that builders and retrofitters can eliminate the hazard and reduce the coincidental energy losses that come with it.

The field study, conducted by John Freeman on behalf of the Alaska Housing Finance Corp., is, in our view, the most thorough and helpful study on the subject since the Minnegasco field study was done in Minnesota in 1996. Freeman studied 12 Anchorage houses to see how CO moves from attached garages into adjoining living spaces. CO levels in each garage and house were recorded over four winter days and the results were used to calculate the percentage of CO transferred from garage to house and the residents' resulting exposure to CO (see Figure 4).

"One of the most surprising findings," Freeman says, "was how consistently and widely the CO dispersed into the house with each release. Even with all the differences in house types, lifestyles, door openings, wind, and other variables, the house CO level consistently tracks the garage release."

Freeman tells *EDU* that CO from car starts in the garages entered all but 1 of the 12 houses. Inside 4 of the houses, the resulting CO exposure was 60% or greater than the exposure limit for outside ambient air

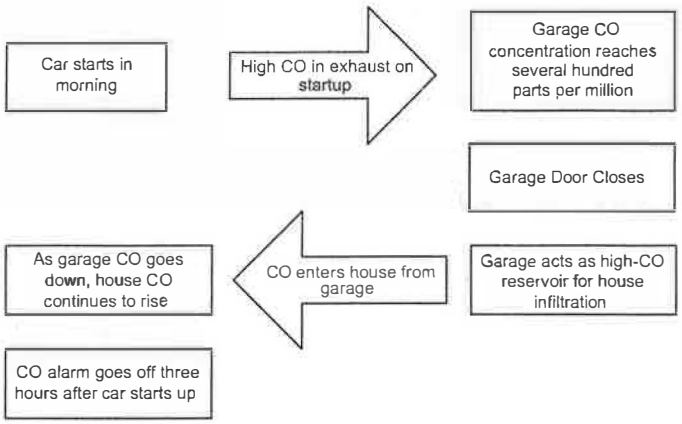

Figure 4 — The process by which CO enters the house via an attached garage. In some houses with very high transfer rates, CO levels inside the house can peak within four minutes after the car starts inside the attached garage. In other houses, it could take hours. Some of the variables that affect the ultimate CO exposure level are: cold motor start versus warm start (exhaust CO levels are very high until the catalytic converter warms up); how old and dirty the car engine is; length of idling time; how leaky the garage is; total area of common wall; porosity of the common wall; pressure balance across the common wall; presence of ductwork in the garage; size and airtightness of the house; and climate.

set by the US Environmental Protection Agency (EPA), and, in one case, CO exceeded the EPA limit. In most of the houses studied, other CO sources were minor compared to the CO from car starts in the attached garage. One exception was a tight house in which the unvented gas range could be a significant source. Another house experienced a spike in CO concentration when running the dryer caused a nearby gas water heater inside the house to backdraft.

Freeman selected the houses to represent current building practices and common house-to-garage construction. The distribution included one- and two-story homes with one-, two-, and three-car attached, heated garages. House sizes ranged in volume from 8,850-23,590 ft^3. Some were built as recently as 1998. The common surfaces included wall and ceiling areas ranging from 164-772 ft^2. Subject houses included a mix of furnace and boiler heating systems with locations in the house or garage.

Freeman employed blower door tests, pressure tests, and CO data loggers to get his results.

One of the most interesting parameters measured was what Freeman refers to as the "transfer score," which is the percentage of CO exposure from a release in the garage that moves into the house. Transfer scores are a function of the size of the common wall, its leakiness, the presence or absence of ductwork, and the pressure differential between the house and garage. In this study, transfer scores ranged from undetectable to 93%. But the range in 10 of the houses was between 12% and 54%. It's noteworthy, however, that the house with the lowly 12% transfer score had the second-highest exposure (73%). In this case, a very high CO level in a small garage attached to a large house reduced the volume-sensitive transfer score. But, exposure to even a small percentage of very toxic garage air could be unhealthy. (One garage reached 610 parts per million-hours or 151% of the US Occupational Safety and Health Administration's Permissible Exposure Limit for 8 hours.)

"In all but one case, the house was operating under negative pressure relative to the garage due to the stack effect," Freeman says. "In other words, the house was sucking CO and other airborne contaminants through the common walls and ceilings. We also found that CO transfer was particularly high where furnace ductwork was located in the garage, because leaks in the ducts provide a ready way for CO to get into the house." In other words, the ductwork was actually working to distribute CO and other contaminants into the house.

R_x for Attached Garages

As with all indoor air quality issues, we recommend the following plan for attached garages: eliminate the source; isolate the contaminates; and ventilate. Ventilation (step 5 below) may be unnecessary if steps 1-4 are followed.

1. Park the car outside. Keep in mind that the car (and other hot motors) continue to throw off pollutants even after they're turned off. Also, tune your car and pay attention to the emissions test.
2. Keep lawn mowers, snow blowers, and other small engine devices outside. Paints, solvents and other chemicals stored in the garage need to be in safe, tight containers.
3. Seal all penetrations through the common wall and ceiling (including the crawlspace). In new construction, use gaskets, airtight drywall technique, etc., to make the common wall and ceiling airtight.
4. Seal all ductwork in the garage with mastic, especially on the return side and around the filter access. Keep the filter clean. (Never install supply or return registers in the garage.)
5. Install a passive roof vent to keep the garage at a negative pressure in relationship to the house. If that isn't possible or doesn't suffice, install a small exhaust fan in the garage that is activated by the garage door closing. A 20-minute runtime is suggested. This will keep the pressure difference in the right direction so that any leakage is from the house to the garage. Take care that the garage isn't depressurized to the point where combustion appliances can backdraft. Better yet, install sealed-combustion appliances.

This nasty situation becomes even worse, Freeman says, if there are forced-air supply registers in the garage itself. "This is one reason I'm a fan of hydronic heating," he notes. "It simplifies pressure and airflow problems."

Transfer scores were also noticeably higher in houses with tuck-in designs — that is, where the garage was tucked into the house under a bedroom or other occupied space above. This design increases both the common wall area and the stack effect. Unless the ceiling is tightly sealed, CO can migrate readily into the room above the garage.

In the lone house where there was no CO transfer, the garage was operating under negative pressure relative to the house due to the presence of a water heater and unit heater that were vented to the outside with no combustion air. The combined draw of these two combustion appliances was able to overcome the stack effect in the house. Thus, most of the CO released into the garage was pulled into the combustion chambers on the water heater and unit heater and vented safely out the chimney.

Freeman describes himself as "really concerned" over these findings, not just because of possible CO exposure, but because other serious contaminants — such as benzene and various volatile organic compounds — also originate in the garage. "I think we have the potential here for significant health impacts when you consider the fact that snow blowers and lawn mowers are also outgassing into the garage, not to mention the paints, solvents, and other chemicals that may be stored there. The occupants in some of these houses are getting a continual stream of pollutants from the garage."

Indeed, a study under way by Health Canada suggests that as many as 150 different pollutants may be available in a garage for transfer into the home. Preliminary results from 25 houses tested in that study found that an average of 13% of all infiltration into the houses was through the common wall between the garage and house (see Figure 5). That percentage, while worrisome enough, is actually less than the 25% typical leakage measured in the Minnegasco study. Either way, that degree of infiltration is going to have an appreciable impact both on indoor air quality (IAQ) and energy consumption.

The good news is that a consensus of sorts is beginning to emerge on how builders and energy retrofitters can best deal with IAQ and energy concerns related to attached garages. These are summarized in the sidebar, "R_X for Attached Garages," on page 7. Of course, the simplest and least expensive fix is to eliminate all sources of pollution in the garage — steps 1 and 2 in the sidebar on page 7. When that's not practical, isolation and/or ventilation have to be considered.

"While I think air-sealing work on that common wall is an important step, the builder or retrofitter must also deal with the pressure balance across that wall," Freeman says. "The surest way to combat the problem is to reverse the stack effect so that the flow is from the house to the garage. It doesn't have to be much of a pressure difference, but it must be there."

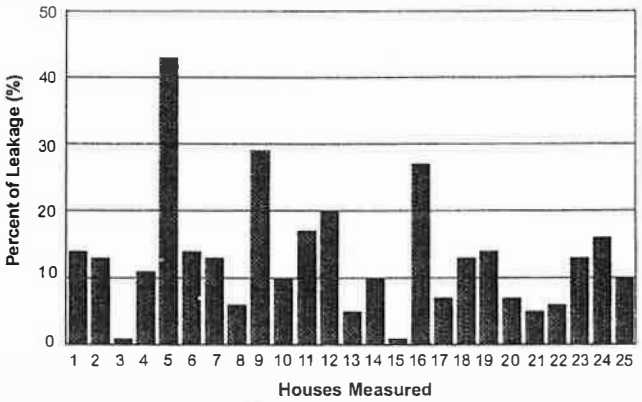

Figure 5 — Despite the fact that Canada's National Building Code calls for an airtight envelope, a new Canada Health study supported by the Canada Mortgage and Housing Corp. found that the common wall between houses and garages accounted for 13% of all infiltration (on average). Note that in some of the leakiest houses the garage-house interface accounted for more than 20% of the total infiltration. In all, 25 houses were measured.

In relatively tight houses, there are a couple of good ways to accomplish this. One is to install an exhaust fan with enough capacity to depressurize the garage 1-2 pascals relative to the house. Of course, whenever you talk about depressurizing a space, great care must be taken not to cause water heaters or other combustion appliances in the garage or house to backdraft. Another approach — one that Freeman finds interesting and intends to test — would be to put a power venting fan on the water heater, which would in effect convert the flue into a powered exhaust port. Of course, this approach only works if the water heater is gas-fired and located in the garage. And there are questions outstanding about how this strategy would affect the water heater's energy efficiency.

The strategies are not as simple with a leaky house, since the stack effect is so powerful that it would require a large fan in the garage to counteract it. Before any corrective action is taken, retrofitters should measure the overall leakage of the shell and the interface leakage between the garage and house. Those numbers will help determine how much air-sealing work is necessary to isolate the garage and what size exhaust fan, if any, is advisable.

Copies of the Alaska Housing Finance Corp. report are available from: John Freeman, Sunrise Energy Works. Tel: (907) 276-7473; Fax: (907) 276-3050; E-mail: rise@ak.net. The complete report can also be viewed as a PDF file online at www.home.gci.net/~sunrise-energy-works/.

Got Garage Problems? Here's One Practitioner's Advice

Dennis Brachfeld, president of About Saving Heat Co. (Denver, Colorado), may have seen the inside of more garages than any other man alive. Over the past 25 years, he's done energy retrofit work on about 22,000 Colorado homes, many of which had problems with attached garages.

"Comfort and air quality problems are the two main reasons we're called in to retrofit so many attached garages," Brachfeld says. "In the winter, that common wall gets cold and leaks cold air into the house. A lot of homeowners could feel the cold drafts coming in around the electrical boxes. In the summer, that wall gets hot and leaks hot air into the house. It gets even worse when you park a hot car or two in the garage. The heat and fumes coming off that engine migrate right into the adjoining living spaces. This can be especially bad with tuck-in garages where you have a bedroom directly above those hot cars."

Brachfeld employs a combination of air-sealing techniques, dense-pack cellulose insulation, and ventilation to address these problems. His $125 air-sealing package includes weatherstripping the door in the common wall, spackling and taping holes in the drywall, and sealing the gaps around plumbing, piping, and ductwork that penetrate the common wall. Brachfeld also recommends that all ductwork in the garage be sealed with mastic so it won't suck up unconditioned air and contaminants and distribute them into the house.

"After we seal the common wall and ceiling, we blow in cellulose, using the dense-pack method," Brachfeld explains. He says that on a lot of jobs he sprays the cellulose right over and around the existing fiberglass batt, compressing it, raising the R-value of the cavity, and providing some air-sealing benefits to boot. "One of the big advantages of dense-pack cellulose is that you can get into those cracks and corners were the fiberglass was cut short or sagged," he says. "Also, with dense pack you automatically find the leaks, because you're applying the insulation under pressure and it squirts out through the holes."

Brachfeld says the density of the dense-packed cellulose in a finished cavity is typically 3.5 lbs per cubic foot, about five times the 0.7 lbs per cubic foot that R-11 fiberglass batt provides. "We usually end up with about an R-30 in a garage ceiling framed with 2x8s and about R-14 in a 2 x 4 common wall," he says. He tells EDU that he charges $10 per linear foot to dense-pack the common wall (door excluded) and $1.80 per square foot for the ceiling over the garage. On a typical 20 x 20-foot, two-door garage this would work out to about $1,000.

"Once we seal and insulate the common walls in the garage, it's much harder for carbon monoxide and other pollutants to get into the house," Brachfeld says. "When you slow that migration down, there's time for those pollutants to disperse through the exterior walls of the garage, which are typically 10 times leakier than the house envelope."

To help vent heat and fumes from the garage to the outside, Brachfeld sometimes installs a passive PVC vent through the roof to act as a natural convection chimney. If there's a room over the garage, making such installation impossible, he puts a small (e.g., 50-100 cfm) exhaust fan in the garage wall that is connected to the control on the garage door light. When the garage door closes and the safety light comes on, the fan also comes on. The light and the fan both shut off automatically a few minutes later. In some garages, Brachfeld has installed the exhaust fan into the back of a storage cabinet or paint locker, so it draws the fumes out. He charges about $150 for the complete fan installation.

Though comfort and air quality are the main drivers behind his garage retrofits, Brachfeld notes that the air sealing and insulation work also provide an acoustical advantage, blocking noise from the garage door, car engines, and power tools. "We also mention the economic payback — that is, the saved energy — to our customers," he adds. "But it's only mentioned as a bonus. The prime motives are comfort and indoor air quality."

For more information, contact: Dennis Brachfeld, About Saving Heat Co., 797 South Emerson Street, Denver, CO 80209-4340. Tel: (303) 777-7475; Fax: (303) 777-7746; Website: www.aboutsavingheat.com.

The Surprising Truth About Vinyl and Stucco Claddings

Though vinyl siding is much maligned by some designers and home builders, it may be a better primary weather barrier than anyone thought. And builders who use stucco cladding will be interested to know that some stuccoed wall assemblies drain up to *100 times* better than others, which makes them much less susceptible to water-related damage.

These and other interesting findings emerged from a series of tests conducted at Building Science Corp. (BSC — Westford, Massachusetts) over the past three months.