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Energy Efficiency:

Proper Construction and Maintenance Yields Less Energy Use

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Learning Objectives

- Review energy creation, transmission and its inherent inefficiencies.
- Evaluate ASHRAE 90.1 best practices for the use of sealants, air barriers and related products in attaining efficient operations.
- Demonstrate how ASHRAE 62.1 best practices not only impact Indoor Air Quality but also energy consumption in a structure.
- Discover the importance of sealants, air barriers, etc. as they relate to total building performance.

Part I- Definitions

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Sustainability Concepts

- Sustainability/Sustainable Building:
  - Practice of designing, constructing and using a building that is balance optimized to account for the **Social**, **Ecological** and **Economic (SEE)** aspects of the building and its components.
    - Relative term… there is no 100% sustainable.
- Conservation:
  - The practice of reserving limited resources for future use by reducing use, reusing or recycling.
    - Constructing buildings to be as energy efficient as possible is conservation of finite carbon-based energy resources.

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Organizations

- DOE:
  - Department of Energy (US)
  - "Owner" of most public research and policy creation on energy reduction/efficient design
    - Seen as the global leader in such research
  - Operate labs like Oak Ridge and Lawrence-Berkley.

- NRCC:
  - National Research Council of Canada
  - Owner of public research and policy creation in Canada
  - Work in collaboration and in some cases lead on energy research with DOE

- EnergyStar™:
  - Program in EPA to promote products, systems and buildings that use less energy.
  - Includes design guidelines, minimal performance criteria, etc.

- ASHRAE:
  - American Society of Heating, Refrigeration and Air Conditioning Engineers
  - Develop specifications and best practices for energy use worldwide.
    - Most pertinent standards are 62.x, 90.x and 100.x

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General Terms

- Sealant:
  - Material used to fill and seal cracks, gaps and voids
  - Can be caulk, mastics, foams, etc. that cure

- Tape:
  - Impregnated Adhesive Foam, Butyl or Asphaltic based that may or may not have a backing… not duct tape!

- Air Barrier:
  - A self-adhered sheet or liquid used to restrict air flow across the entire surface of a building before the cladding goes on… not stapled on sheets!

- HVAC:
  - Heating, Ventilating and Air Conditioning
  - Any system intended to move air into, out of or within a building or part thereof.

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General Terms

- Heat Island Effect:
  - Local increase in temperature due to dark surfaces translating light energy into heat energy.
    - Primarily roofs and pavement.
    - The darker the surface, the more intense the effect.
  - Also means you have a hot roof… energy hog in Summer.

- Building Envelope:
  - The surface of the building across which air and water pass to enter into the occupied interior space.

- High Performance Building:
  - Designed as one system with optimized air sealing, insulation and maintenance.

Part II: The Science

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Everything is a System…

- Buildings are a system
  - Only as energy efficient as alowed by the weakest link
  - Must have insulation *and* proper air sealing
    - Neither can make up for a lack of the other.
  - Insulation and sealing slide toward a point of zero return

- Need to minimize both convection (air sealing) as well as conduction (insulating) to get optimal performance

- Your HVAC system must also be sealed properly so it works as it is designed.
  - Properly constructed/maintained HVAC systems help achieve a *high performance building*.

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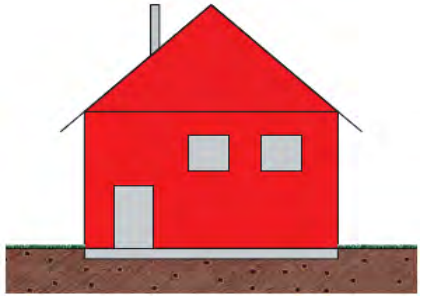
Convection vs. Conduction

Sealing Properly… Tiny Gaps Add Up

Example:



An average house…

- **Window Perimeter Gaps** ➢ **approx 100m (330 ft)**
- **Leakage at approx. 10%** ➢ **approx 10m (33 ft)**
- **Gap width** ➢ **approx 1-2mm (1/16 in.)**
- **pressure difference** ➢ **6 Pa**

Estimated energy loss of 2600 kWh/yr. or

8.878 million BTU/year or

US$300

or 1228kg (2700lbs) CO_2/yr.

Fact: 33 ft. of 1/16” gaps equates in one year to the amount of carbon dioxide you exhale in over 3 years!

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Cold v. Hot Climate (Gas v. Electric)

- The CO_2 produced and energy consumed depends on a lot of factors:
  - If you are in a cold climate:
    - You likely have greater temperature differences
    - You likely use more overall efficient fossil-fuels (i.e. natural gas)
  - If you are in a warm climate:
    - You use more electricity-based A/C,
      - Inherently inefficient to even non-electric heating and has a higher carbon footprint…
  - Let's look at the scientific reasoning behind this…

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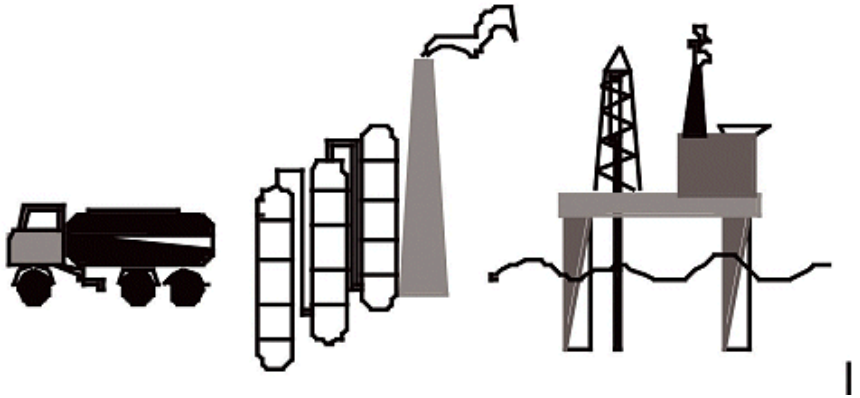
Heating- *Direct* Fossil Fuel Use

- Mining/Extraction (Fossil Fuels)
- Preparation
- Transport
- Consumption (effectiveness of modern boilers and furnaces is 80%-90%)



CO_2 Multiplier for fossil fuels : ~ 1.3

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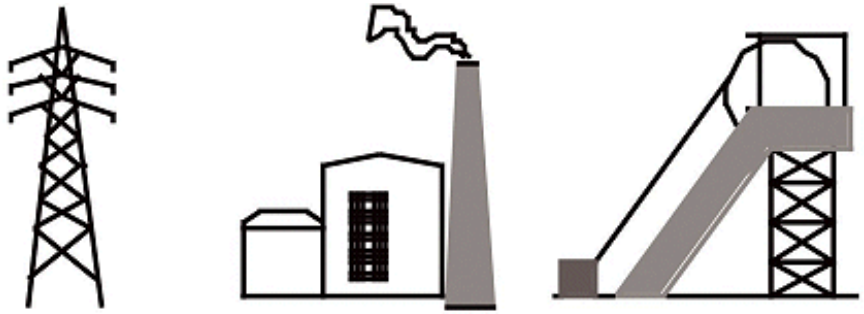
A/C- *Indirect* Fossil Fuel Use

- Mining/extraction of fossil fuels
- Transport to power plant
- Generate into power (overall efficiencies of fossil fuel power plants ~40%)
- Transport the power via power line (losses approx 8%)
- Effectiveness of electrical heaters 95%+… AC is very regionally dependent!



Factor for Electricity: 3.0 to ???

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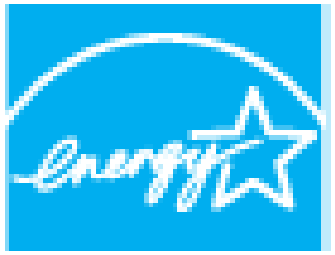
What Does the Science Mean?

- When considering carbon footprint one has to calculate *actual* attributable carbon based on the primary energy source.

- Example:
  - Electricity has a multiplier of 3 as shown on the last slide.
  - Take an electric HVAC unit that has a point-of-use consumption of approx 600 kW/yr
  - Has an actual attributed carbon footprint as if it used 1800 kW/yr because of the inefficiencies in electric generation.

- So, regardless of climate or system, sealing is important to reduce energy use and subsequently carbon footprint. But how and how much does each step help???

Part III: Sealing Right…



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Sealing Properly

- EnergyStar states that properly placed and maintained exterior caulking can save 20%-25% of your HVAC costs in small commercial buildings and homes.
  - ASHRAE standards define equipment as well as best practices:
    - 90.1 and 90.2 for new construction
    - 100.1 and 100.2 for renovation/remodeling

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Use ASHRAE 90.1 as Basis…

- We'll base our discussion on 90.x, understanding 100.x is just this adapted to existing structures.
  - *The principles of sealing properly and the benefits attainable are identical whether the building is new or existing.*
  - The two standards read very similarly because of this.

- ASHRAE 90.1…
  - Referred to as the energy efficiency standard
  - It also tells you best practice for maximizing efficiency
  - It also assumes you use an air/vapor barrier of some kind.

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Use ASHRAE 90.1 as Basis…

- 90.1 Section 5.4.3.1- Seal with caulk, mastic or a tape”
  - “Joints around fenestration and door frames”
  - “Junction between walls and foundations, between walls at building corners, between walls and structural floors or roofs and between walls and roof or wall panels.”
  - “Openings at penetrations of utility services through roofs, walls and floors”
  - “Site-built fenestration and doors”
  - “Building assemblies used as ducts or plenums”
  - “Joints, seams and penetrations of vapor retarders”
  - “All other openings in the building envelope.”


Dynonic FC


CalMarc
Performance
Plus Homes
ARCA

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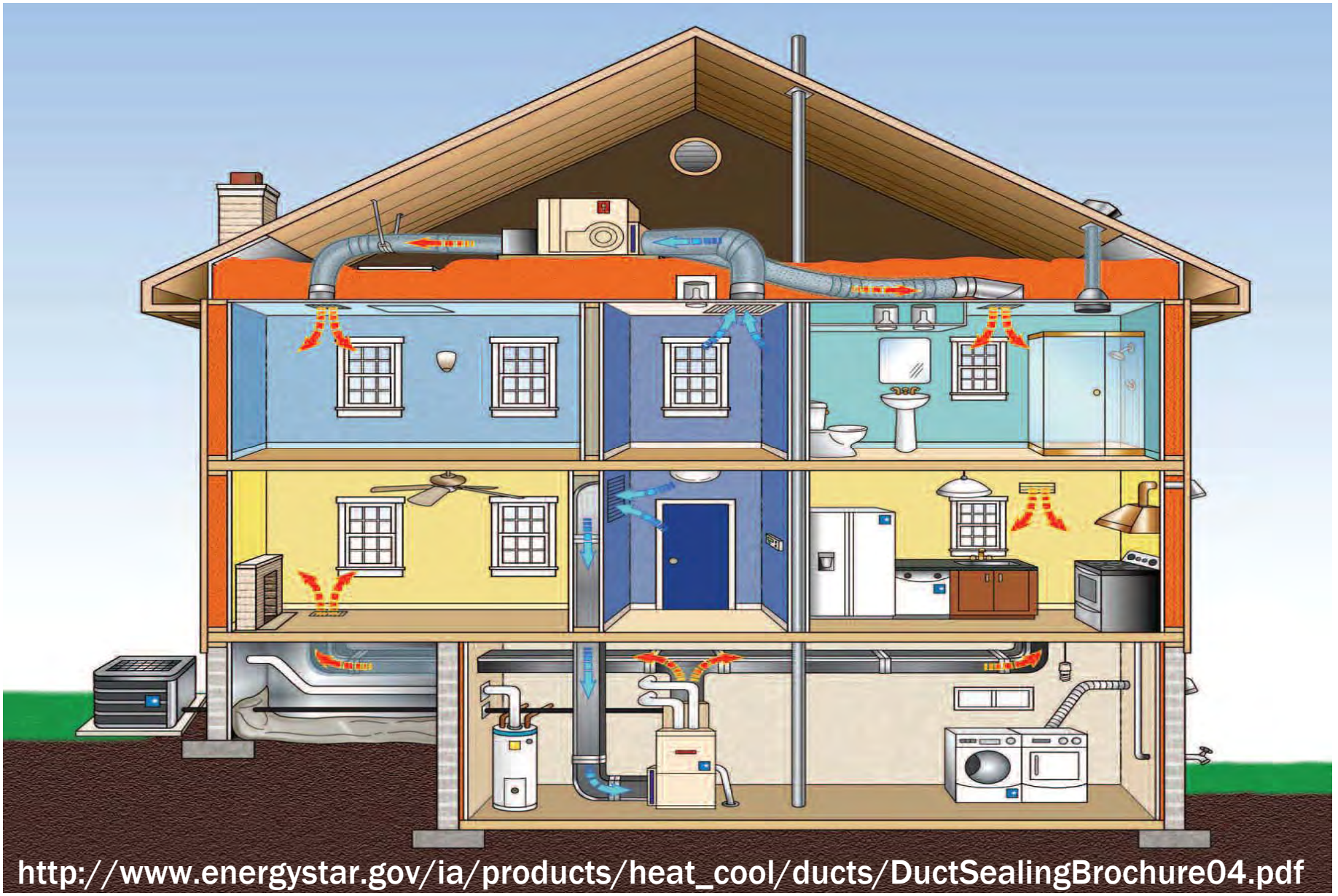
HVAC Sealing

- 90.1 Section 6.4.4 discusses HVAC and ventilation assembly best practices
  - References SMACNA standard stating these shall be sealed the same as the building exterior:
    - Connection between the ducts and HVAC unit
    - Connections between duct segments
    - Connections between ducts and registers
    - All adjustable joints in elbows, etc.
    - All joints between intakes and intake ducts
    - Around all intakes and the building.
    - Around all ducts, etc. where they go through floors, walls, ceilings, etc.
    - All similar joints in ventilation (i.e. fume hoods, etc.)


http://www.energystar.gov/ia/products/heat_cool/ducts/DuctSealingBrochure04.pdf

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Sealing Tests

- Blower Door Test
  - Pressure differential measured and compared to theoretical.
  - Leakage rate calculated based on this difference.
  - High performance buildings have a leakage rate of < 0.25 CFM/Sqft at 75 Pascals (as defined by the Army Corps of Engineers).
  - Less leaks = More control of air flow = Less energy wasted!
  - NOTE: Duct systems tested similarly (ASTM E1554).

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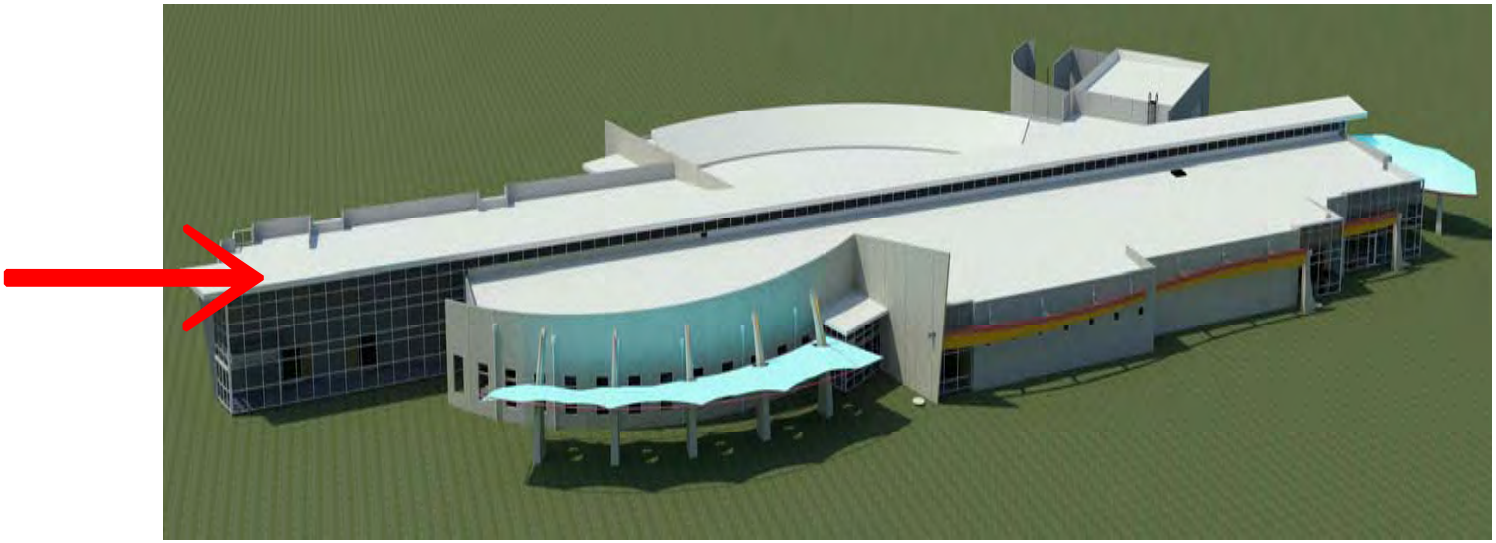
Beyond Sealing…

- 90.1 Section 5.5.3.1.1 and heat island effect… this translates into AC savings as well.
  - Should use highly reflective/low emissivity roofing
    - White coatings on flat roofs
  - Usually South of 50th parallel in North America yields a positive return per LBNL.

- 90.1 Section 5.5.3.3 on below grade wall insulation
  - "Below-grade walls shall have a rated R-value insulation not less than…" specified in the standard.



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And the Total *Possible* Savings…

- All per work done by various government agencies with industry associations shows, depending on climate, etc:
  - Sealing the Envelope: 25% HVAC reduction possible
  - Sealing HVAC: 20% HVAC reduction possible
  - Roof: 15% HVAC reduction possible
  - Air Barrier: 40% HVAC reduction possible
  - Total Potential HVAC Reduction (not cumulative): 69%
  - Total Energy Reduction (HVAC averages 40% of utility costs across North America): 28%

Part IV: Additional Information

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Proper Sealing Also Saves the Air…

- Ventilation Effectiveness
  - Insure air is distributed as the system is designed and as such occupant comfort maintained.
  - Via ASHRAE 90.1 and 62.1, sealants help maximize HVAC efficiency and operation by controlling air leakage in the envelope and HVAC unit itself.

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Proper Sealing Also Saves the Air…

- Indoor Chemical/Pollutant Source Control
  - Occupant comfort is increased if kitchen odors, cleaning smells, etc. are kept where they are supposed to be.
  - ASHRAE 62.1 Section 6.3 and 7.1
    - Address design techniques and methods for minimizing air leakage inside of buildings
      - Include the use of sealants, tapes and mastics between wall/floor intersections, on ducts/exhaust pipes, etc.

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Resources…

- EnergyStar- The best consumer resource
  - www.energystar.gov
- NRCC-
  - http://www.nrc-cnrc.gc.ca/eng/index.html
- The Department of Energy
  - www.doe.gov
- Tremco
  - http://www.tremcosealants.com/commercial/green/default.asp
- Local Utility
  - http://www.firstenergycorp.com/index.html

Part V: In Conclusion…

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Today's High Performance Buildings

- These save money, reduce the carbon footprint and improve comfort.
- Proper insulating and air sealing coupled with the proper implementation of related construction practices will result in energy savings regardless of climate or energy type.
- It is possible to reduce the needs of energy for heating and cooling in North America by up to 70%, saving building owners and occupants, reducing our carbon output by nearly 30%.
- This greatly contributes to the high performance building that will be comfortable, durable, meet future climate considerations and allow for freedom in design such as daylighting.

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Thank You!

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