

# Intuitive ontologies for energy in physics

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## Conceptualizing energy

What kind of thing do people think of energy as being?

... and what is the significance for instruction?

## Theory and practices

Learning and expertise show best in what people do and say to learn together. [1]

We mostly analyze classroom discourse.

People understand the kinds of things that may exist in terms of sensorimotor experiences.

We examine physics discourse for embodied metaphors. [2-5]

People have good reason to think of things the way they do.

We identify the advantages and limitations of specific metaphors.

People have easy cognitive access to a variety of ontologies. [4]

We promote disciplined, flexible use of metaphorical language in instruction.

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## Data: Physics discourse

Leaves blowing in the street:  
How is energy involved?  
(8th grade, public school)

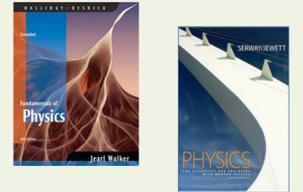


Tamara: All right. Leaves in street. I don't think so. Cause it's just the wind.  
Laila: Yeah. I don't think I don't think the leaves in the street have energy. They have a type of energy, but-  
Kelsey: But is wind energy?  
Laila: Wind is energy.  
Tamara: Oh, should we write it down?  
Kelsey: Well they're getting wind energy.  
Pierre: But it's not talking about the wind.  
Laila: -about the wind, it's just talking about the leaves in the street. Leaves - leaves in the street, do they have energy.  
Tamara: No.  
Pierre: They are pushed by energy  
Laila: They have energy, but they do not have the energy, like, to move.

Laila: But wind - I don't think wind has energy. Well it has energy  
Kelsey: You can use wind to like power stuff  
Laila: Is it - to create energy. Wind-  
Kelsey: It can be a source of energy.  
Laila: Yeah, your wind is like your foot on the pedals.  
Kelsey: Yeah. It's a source of energy.  
Laila: I don't really think-  
Kelsey: I mean the leaves have a source of energy.  
Laila: The leaves have a source of energy but they don't have like energy to move they're talking about its motion. Is motion energy there and I don't think the leaves have motion energy.

Kelsey: But the leaves were moving.  
Laila: But they're moving because of the wind. I'm saying if you could have-  
Kelsey: That is their source of energy.  
Laila: -leaves in the street without, without, if we had leaves without the wind, it wouldn't move then. I'm just thinking of both cases.  
Kelsey: True but I mean but like a bus without gasoline wouldn't move either.  
Laila: No, true.  
Kelsey: And like a bicycle without pedals, a pedaler, wouldn't move either. So.  
Laila: I don't know I just feel like a leaf wouldn't  
Stephanie: It seems like it is but  
Laila: But I feel like in my mind I feel like it's energy! It's involved in a type of energy. I'm going to put yes-slash-no, because it's involved in a type of energy.

Additional physics discourse (about energy levels) from standard college texts



## Energy as a substance



Energy is a kind of stuff (invisible, massless, etc.); objects are containers that can have such stuff in them. [5-8]

**Grammatical indicators:**  
Energy is *in* objects; objects *have* or *get* energy.

Leaves in the street *have* energy.  
They're *getting* wind energy.

**SUPPORTS** conservation, presence in objects, transfer, flow

Ontologically similar to **electric charge**:

*permeates material objects and changes their quality without adding significant mass or volume*



### Variation: Fuel

- Literal material substance
- Stores "useful" energy
- Used up (transformed into non-fuel substances)



Wind can be a *source of* energy. You can *use* wind to *power* stuff. Leaves wouldn't move without *wind* as a bus wouldn't move without *gasoline*.



Can be productive if learners can think of fuel as *having* energy rather than *being* energy

## Energy as a stimulus



Energy has an effect on objects: it makes things happen.

**Grammatical indicator:** Energy *acts on* objects.

Leaves in the street *are pushed by* energy.  
Wind *is* energy.  
Wind is like your *foot on a pedal*.  
Leaves wouldn't move without *wind* as a bicycle wouldn't move without a *pedaler*.

**SUPPORTS** sociopolitical discourse (necessity of energy for activity), association of energy with forces ("ability to do work")

Ontologically similar to **force** or *agent that exerts force*:

*General trigger or impetus for action*



### Variation: Activation/Fulfillment

Energy is a stimulus whose effects are specific to the object being stimulated:  
steel becomes magnet, lights turn on, cars move, rubber stretches



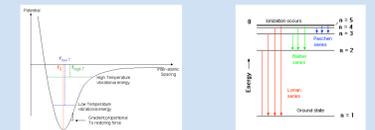
## Energy as a vertical location



Energy is an ordered set of vertical locations. [5]

**Grammatical indicator:**  
Objects are *at* energies.

The kinetic energy of the cart gets *higher* as the cart speeds up.  
The electron makes a transition *from* the n=2 energy level *to* the ground level (n=1). [9]  
One way an electron makes a quantum jump *up to* a greater energy level is to absorb a photon. [10]



**SUPPORTS** first law of thermodynamics (increasing energy takes effort)

Ontologically similar to **electric potential**

- ✦ **Multiple and overlapping metaphors** for energy complement one another in complex representations of physical phenomena. [4]
- ✦ **Each contributes to a valid understanding** of energy in physics.
- ✦ Instructors who appreciate each metaphor's **advantages and limitations** are better prepared to use them as a resource for instruction.