TOPIC # 9

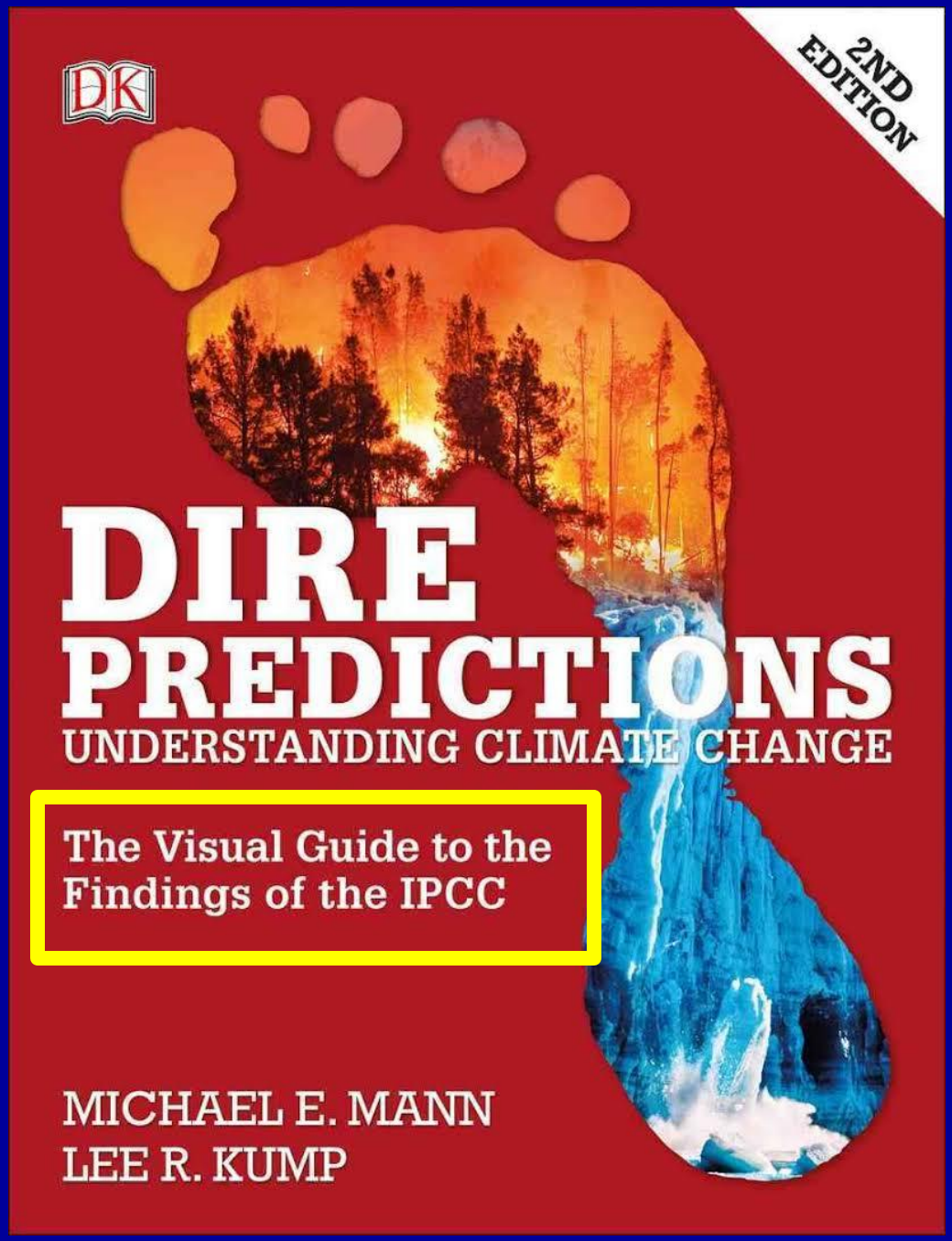
An Introduction to Models:

UNDERSTANDING SYSTEMS & FEEDBACKS

Class notes pp 53-55

“When one tugs at a single thing in nature, one finds it attached to the rest of the world.”

~ John Muir



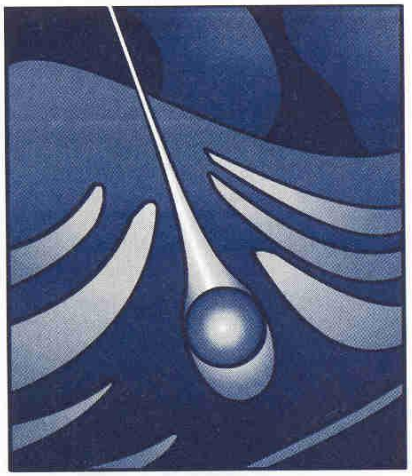
Projections of what the FUTURE CLIMATE will be like are based on COMPLEX COMPUTER MODELS – results are given in the IPCC Report and summarized in your DIRE PREDICTIONS text .

(More on these projections later under Topic # 13)

THIS CHAPTER INTRODUCES YOU TO

"THINKING LIKE" the IPCC COMPUTER MODELS to PROJECT FUTURE CLIMATE

CHAPTER 2



Daisyworld:
An Introduction
to Systems

(Appendix C in SGC E-Text)

WHAT IS A SYSTEM?

SYSTEM = a set of interacting components

COMPONENT *(def)* = An individual part of a system.

A component may be a reservoir of matter or energy, or some other aspect of the system, a "system attribute" or a subsystem:

e.g. the atmosphere, the energy in the atmosphere as measured by temperature, or the amount of CO_2 in the atmosphere, etc.

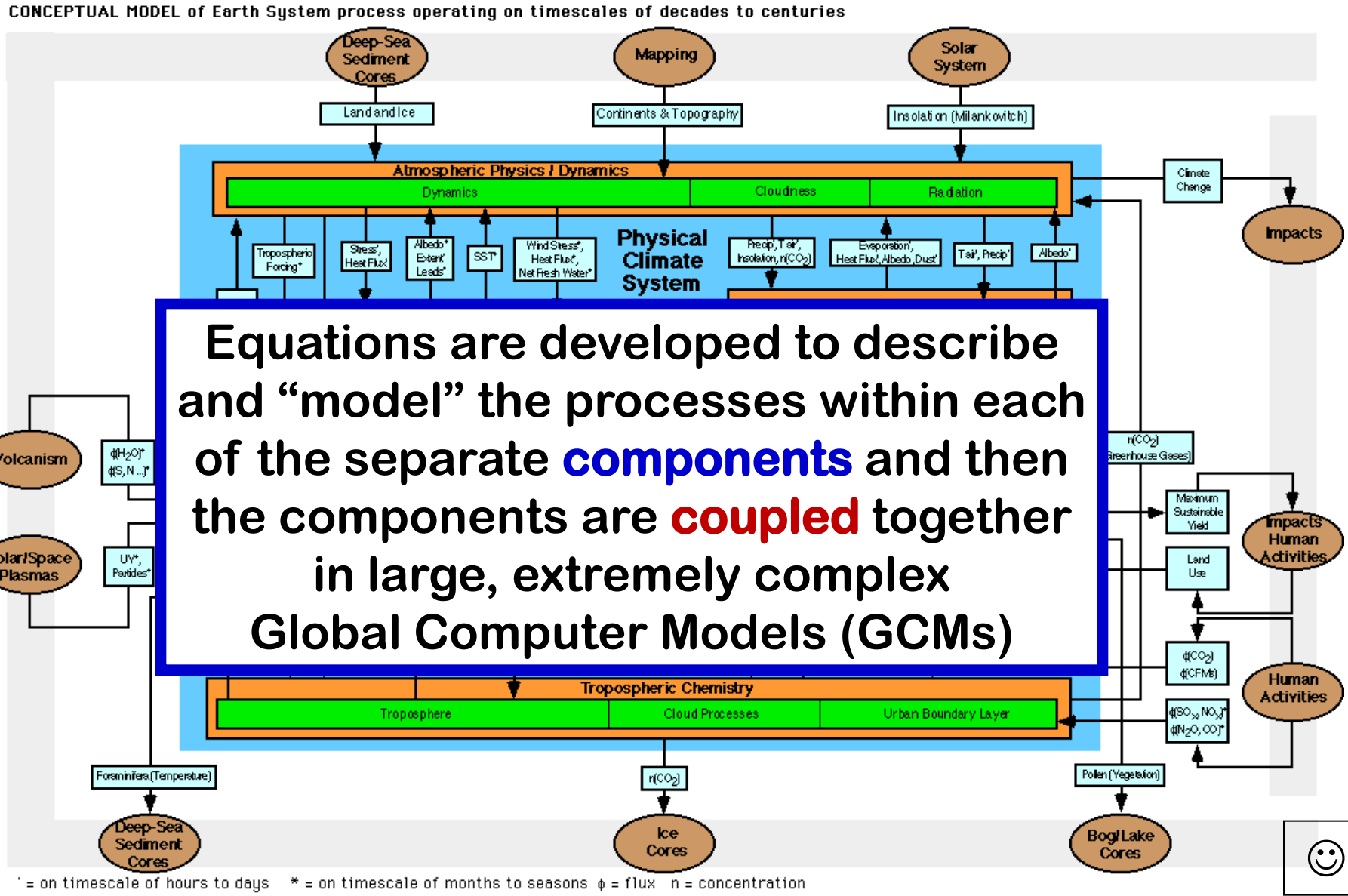
SYSTEM MODEL =

a set of assumptions, rules, data and inferences that define the interactions AMONG the components of a system and the significant interactions between the system and the "universe" outside the system

SYSTEM DIAGRAM =

A diagram of a system that uses graphic symbols or icons to represent components in a depiction of how the system works

A complicated "system diagram" of the Earth-Atmosphere System:



Coupling *(def):*

The links between any two components of a system.

Couplings can be positive (+) or negative (-)

A coupling between an electric blanket temperature component and a body temperature component:

If the electric blanket's temperature INCREASES . . .

The person's body temperature will also INCREASE

What type of COUPLING IS THIS?

Positive + OR Negative - ???

A coupling between a person's body temperature and an electric blanket's temperature

If the person's body temperature INCREASES and she gets too hot . . .

The electric blanket's temperature control will be turned down and the blanket temperature will DECREASE

What type of COUPLING IS THIS?

Positive + OR Negative - ????

➔THE "RULE" – how to tell if it's a positive or negative coupling:

Positive couplings have:

a solid "arrow" & normal arrowhead

arrows points in the direction of the coupling:

Negative couplings have:

an "open circle" for the arrowhead

arrow "points" in the direction of the coupling:

FEEDBACKS

Feedback mechanism *(def):*

a sequence of interactions in which the final interaction influences the original one.

Feedbacks occur in loops ➔

Feedback Loop *(def)* =

A linkage of two or more system components that forms a ROUND-TRIP flow of information.

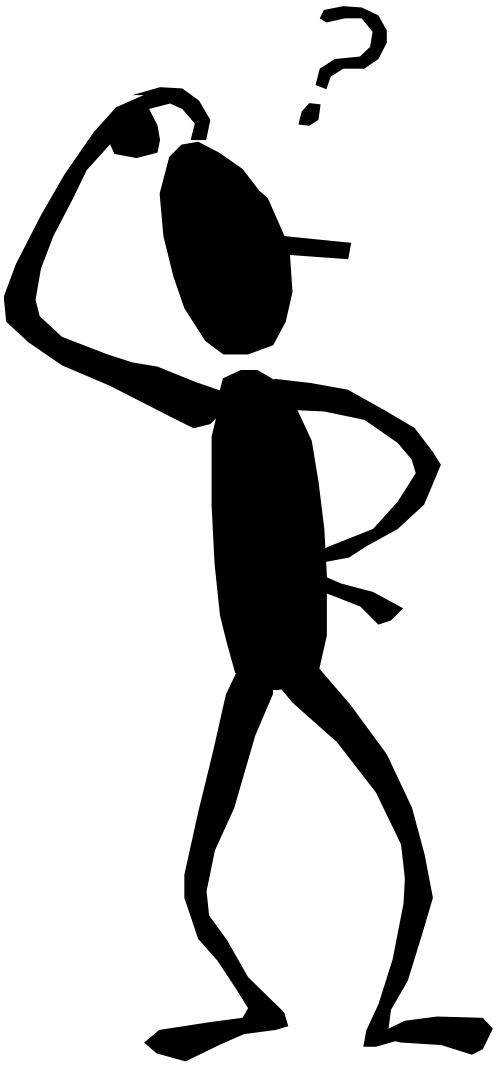
Feedback loops can be positive (+) or negative (-).

A ***positive feedback*** :

- **amplifies** the response of the system in which it is corporated
- **self-enhancing; amplifying**
- ➔ leads to an **"UNSTABLE Equilibrium STATE"**

A ***negative feedback:***

- reduces or dampens the response of the system in which it is incorporated
- is self-regulating (diminishes the effect of perturbations)
- ➔ leads to a "STABLE Equilibrium STATE"



One way to remember the effect that a NEGATIVE feedback loop has is to think of the word "negligible"

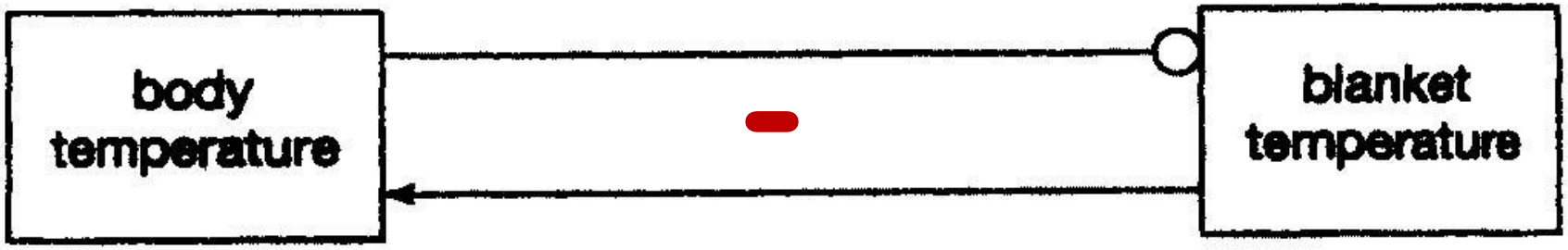
i.e., a perturbation or disturbance in a system characterized by a negative feedback loop will be able to adjust to the perturbation and ultimately the effect on the system will be negligible

FEEDBACK LOOP

Clicker Q1

What kind of FEEDBACK LOOP is it?

1) Positive (+) 2) Negative (-) ???

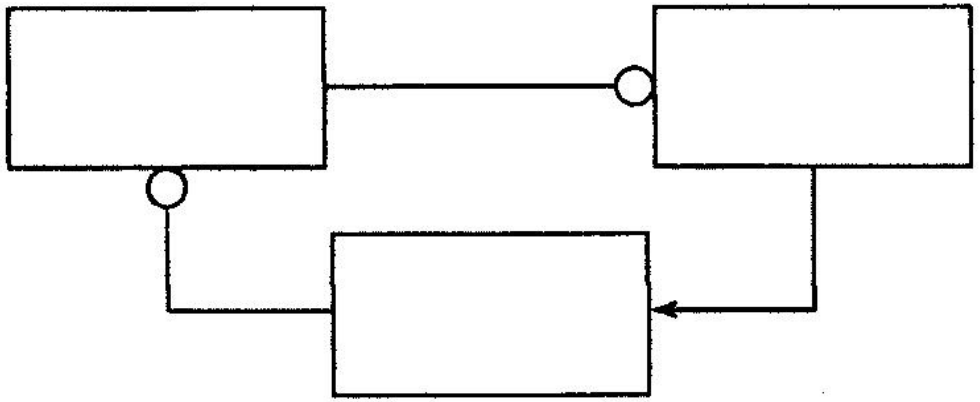


THE "RULE" – how to tell if the diagram is a positive or negative feedback LOOP:

Count the # of number of NEGATIVE COUPLINGS:

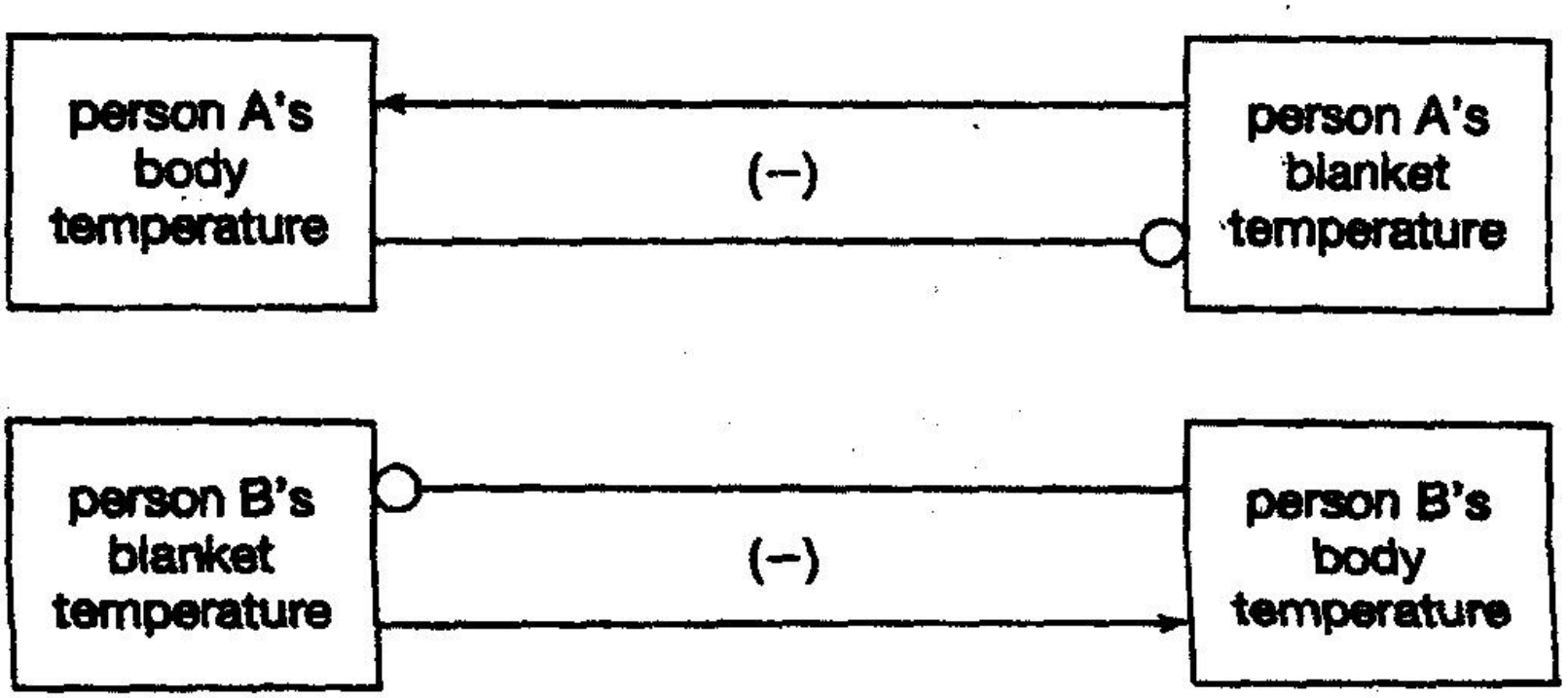
If there is an ODD # of negative Couplings, the loop is NEGATIVE:

If there is an EVEN # of negative couplings, the loop is POSITIVE



Everyday life example:

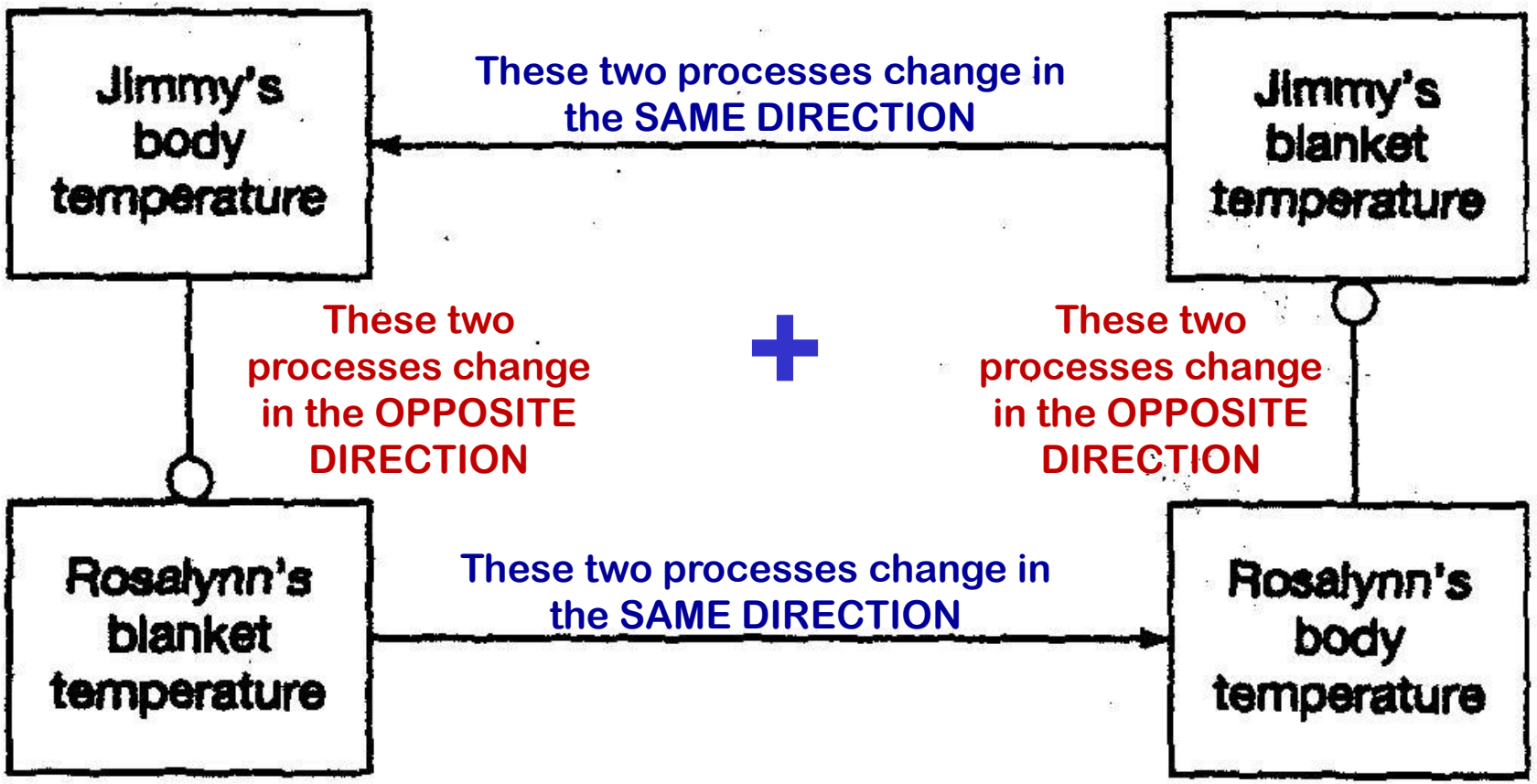
Proper alignment of dual control electric blanket:



Improper alignment:

Clicker Q2 What kind of FEEDBACK LOOP is it?

1) Positive + 2) Negative -



A POSITIVE FEEDBACK LOOP that amplifies the effect!

QUICK SUMMARY:

- **NEGATIVE** feedback loops:
  - are **resistant to a range** of disturbances
    (small changes have a "negligible" effect)
  - system can return to it's beginning state
  -- STABLE equilibrium state

+ **POSITIVE** feedback loops:

  - **amplify the effects of disturbances**
    (small changes can "amplify" the response)
  - system can become UNSTABLE and
    be taken to a new, amplified state

LINKING TO GLOBAL CHANGE:

In Global Change science we are concerned about disturbances that both humans and natural factors can produce in the Earth system:

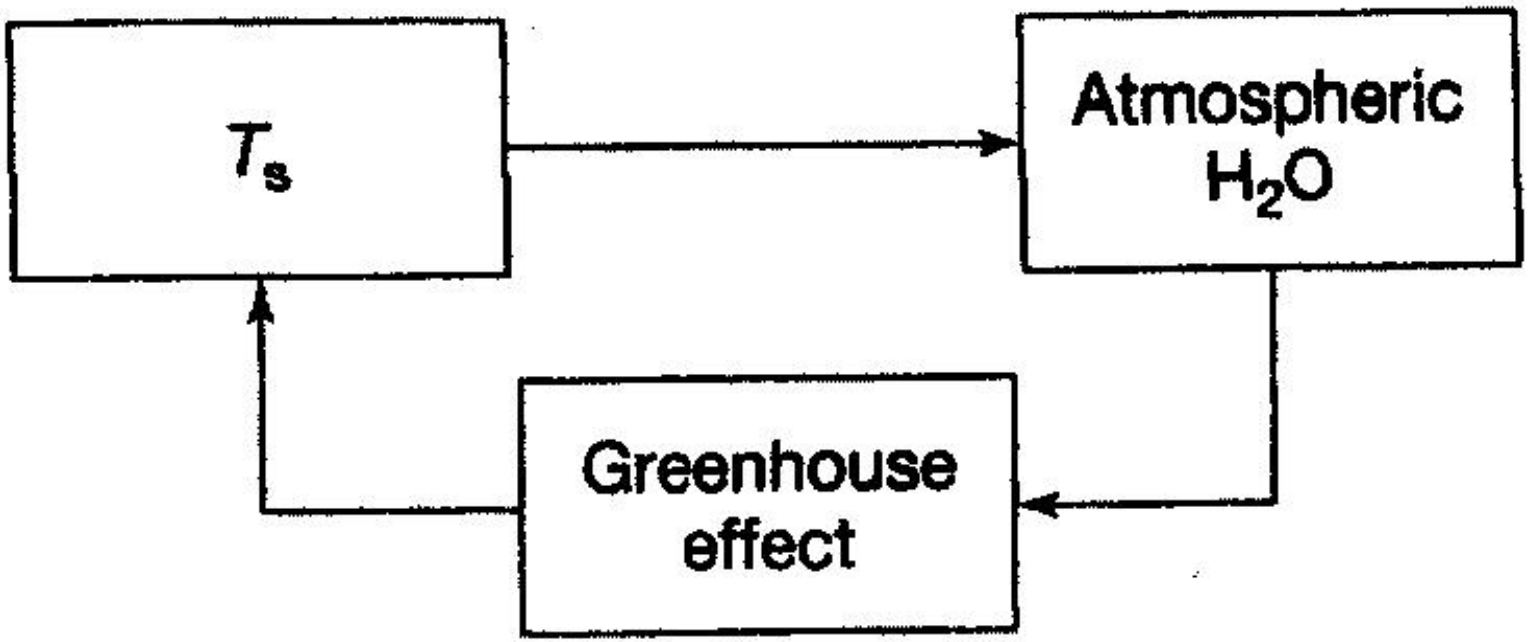
(e.g. increasing carbon dioxide)

. . . and whether or not the Earth can adjust to these and have a stable equilibrium state, or be thrown into an unstable state due to positive feedback loops

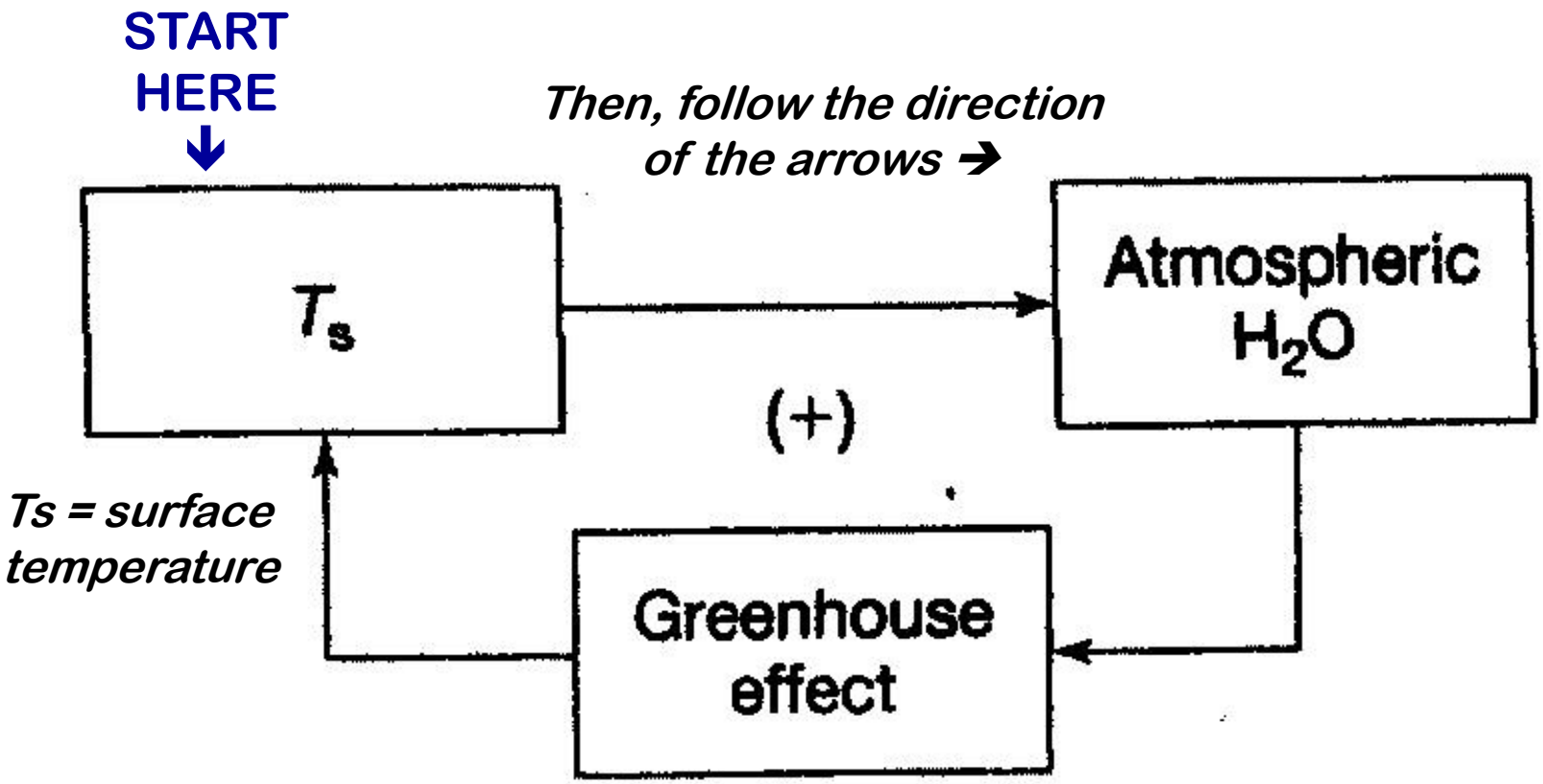
WATER VAPOR Feedback in the Earth-Atmosphere

Clicker Q3 What kind of FEEDBACK LOOP IS THIS?

1) Positive + 2) Negative -



POSITIVE FEEDBACK LOOP
that amplifies the effect!

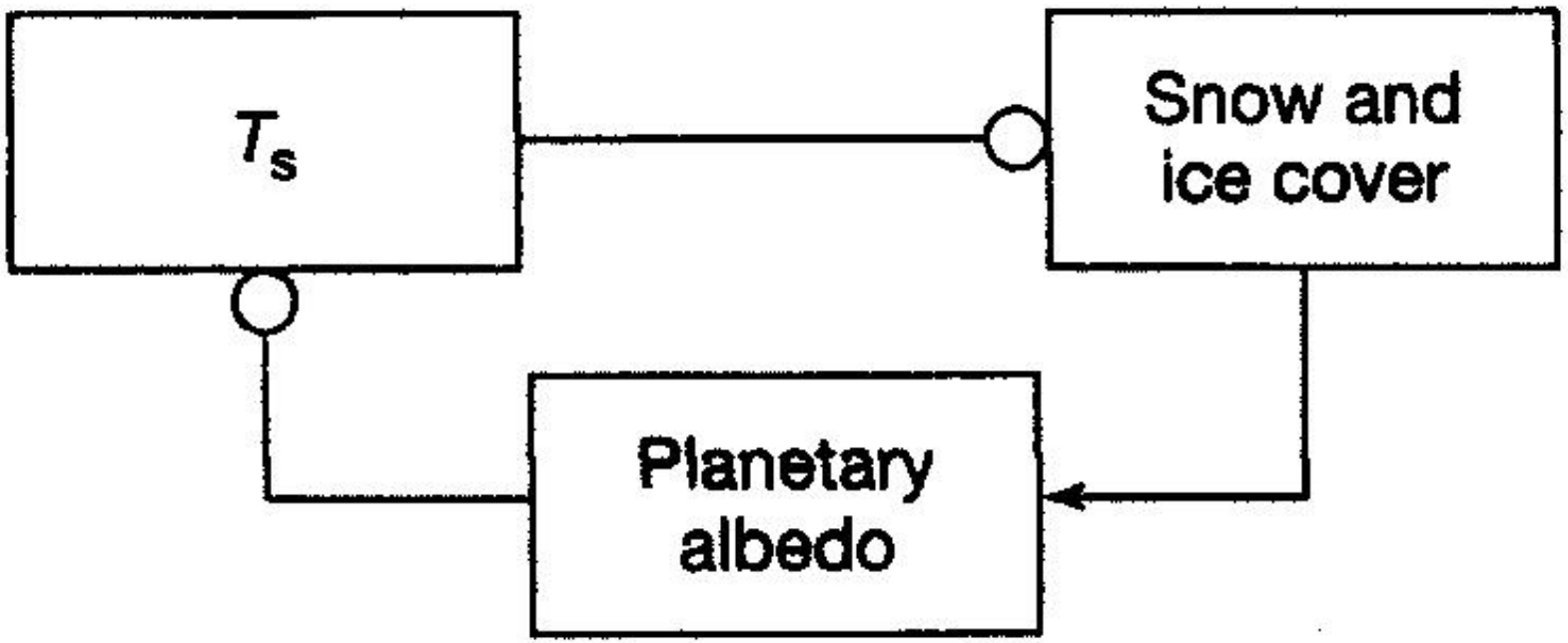


Let's reason it through . . .

SNOW AND ICE ALBEDO Feedback

Clicker Q4 What kind of FEEDBACK LOOP IS THIS?

1) Positive + 2) Negative -



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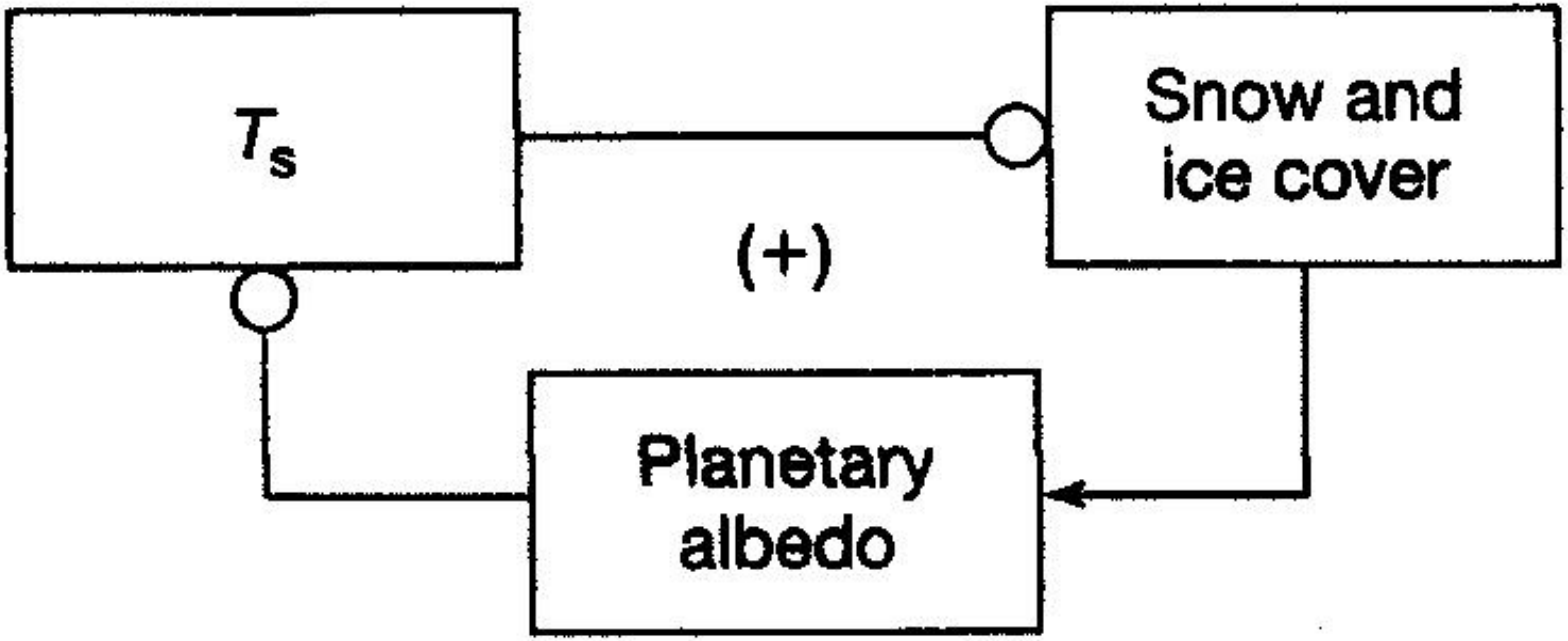
ALSO a POSITIVE FEEDBACK LOOP that amplifies the effect!

but

HOW DOES IT WORK?



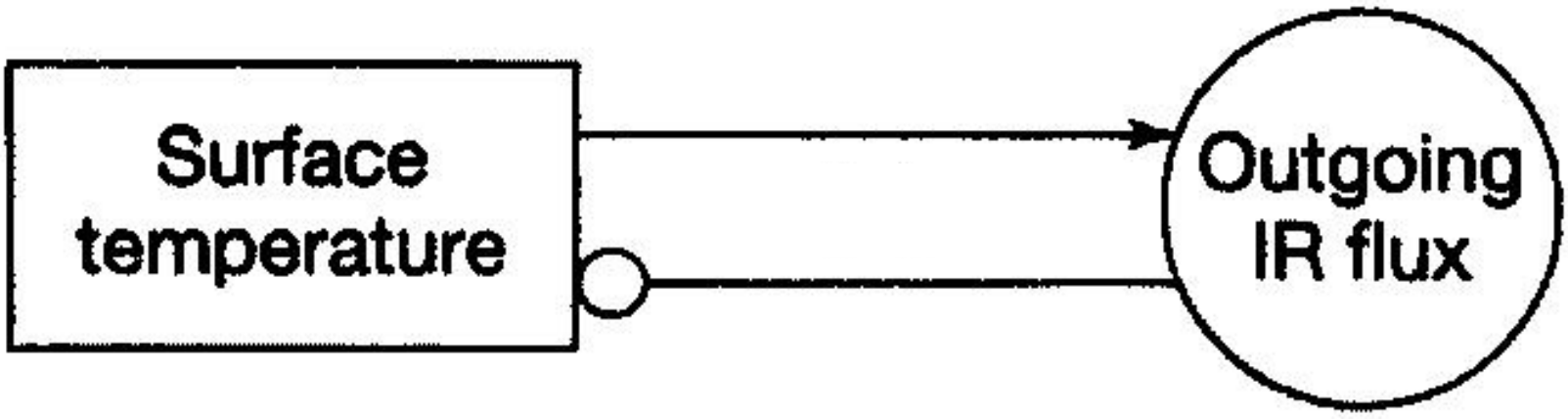
ALBEDO REVIEW:

Fresh Snow & Ice = very high albedo (0.80 - 0.85)

OUTGOING INFRARED ENERGY FLUX / TEMPERATURE Feedback

Clicker Q5 What kind of FEEDBACK LOOP IS THIS?

1) Positive + 2) Negative -



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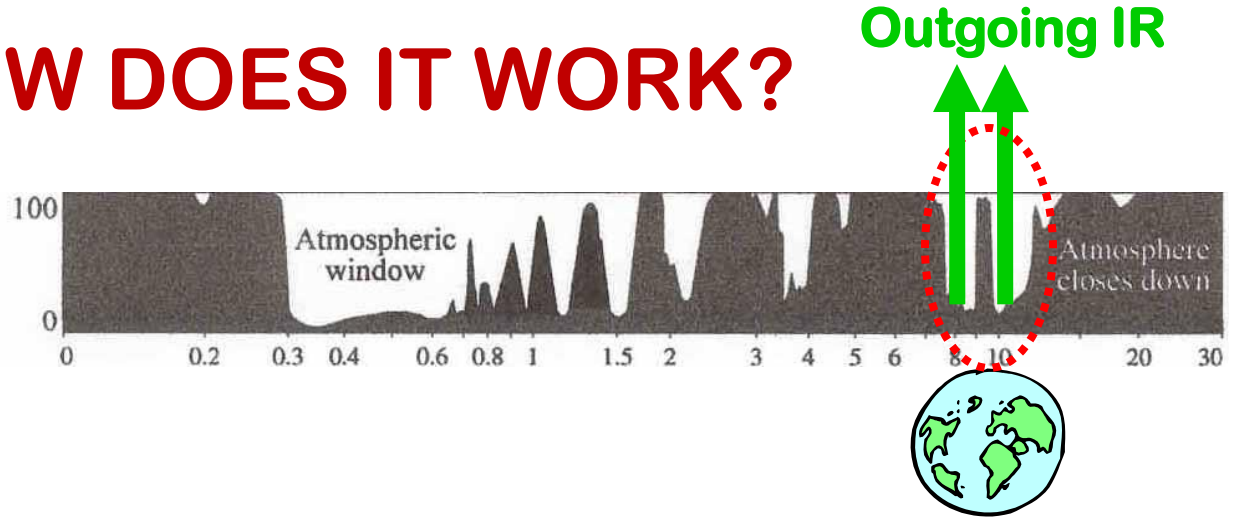
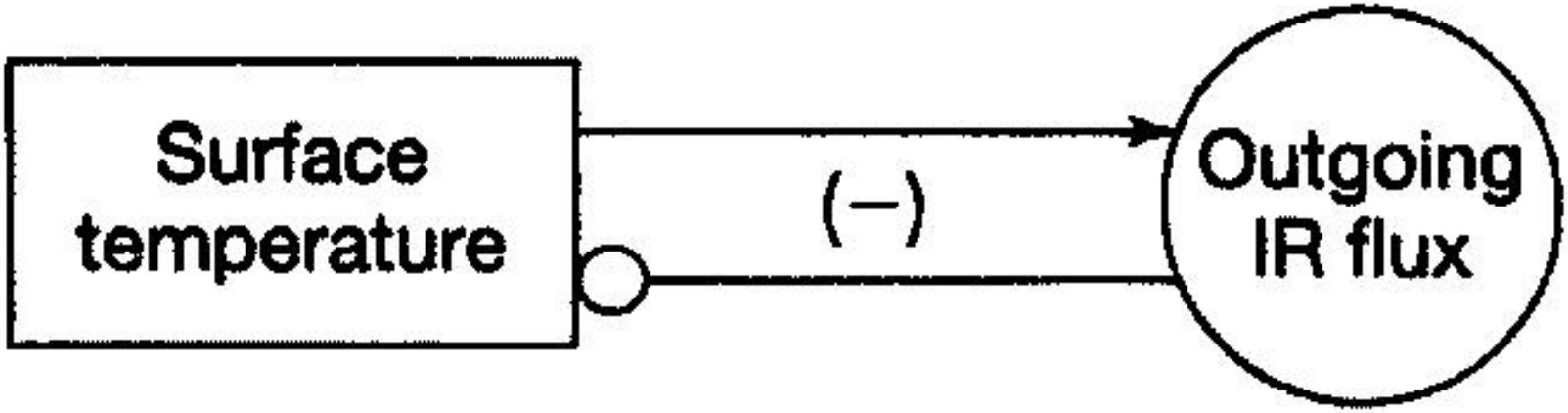
NEGATIVE FEEDBACK LOOP

that is self-regulating!

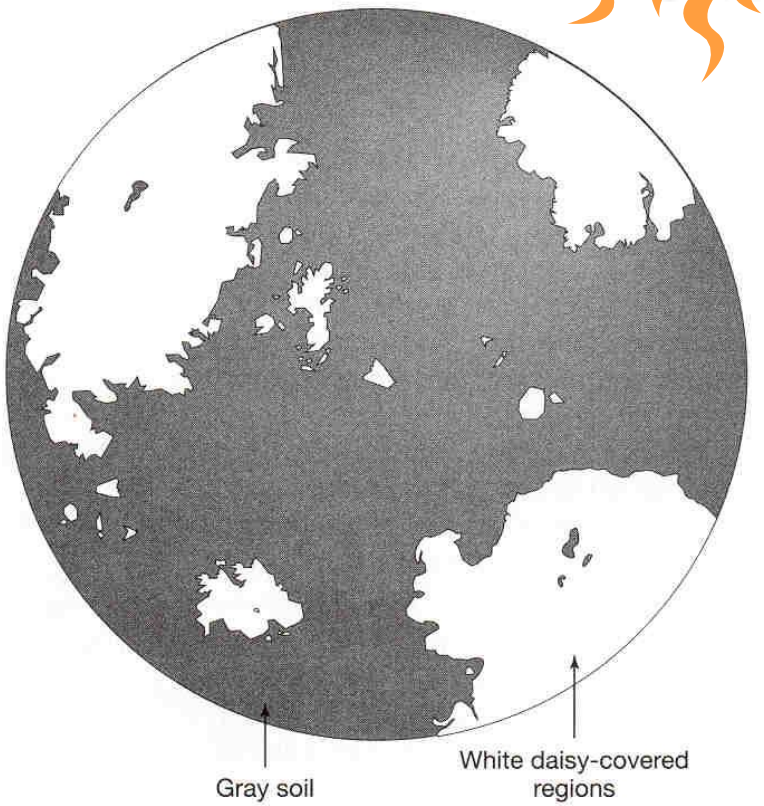
HOW DOES IT WORK?





This is how the **EARTH cools itself!**

We'll talk about the Daisyworld Climate System later . . .



TO BE CONTINUED . . . . .

The final segment of:

http://www.pbs.org/wgbh/nova/solar/

INDEX CARD Writing Practice
"Making a position statement"

Put your name at the top,
then write out and defend your answer
articulately & thoughtfully in a few sentences:

SHOULD THE UNITED STATES BE MORE LIKE GERMANY IN ITS APPROACH TO SOLAR ENERGY?

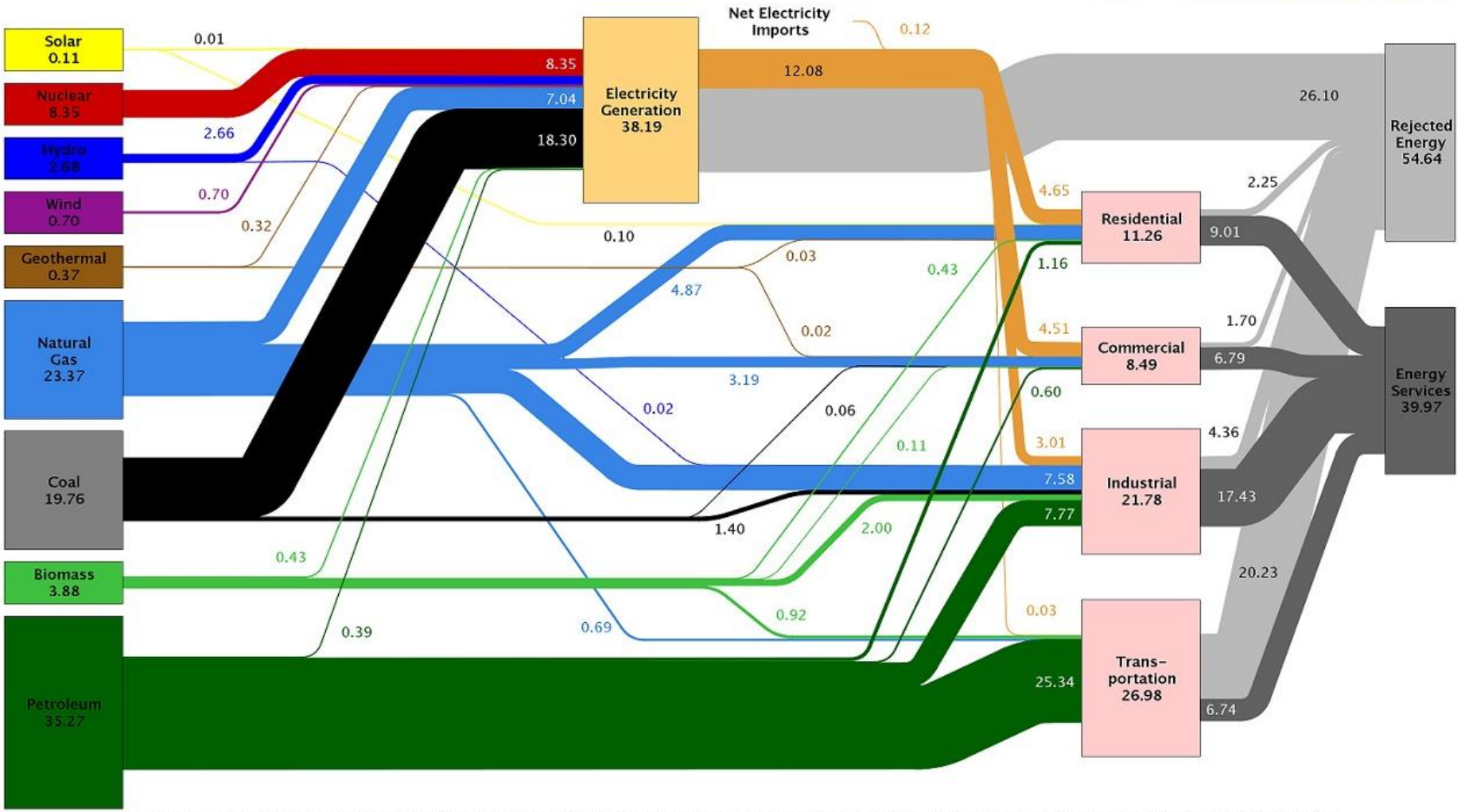
Yes or No & WHY or WHY NOT!

WHERE IS THE USA ON SOLAR?

Find out on p 102 in CLASS NOTES!

Estimated U.S. Energy Use in 2009: ~94.6 Quads

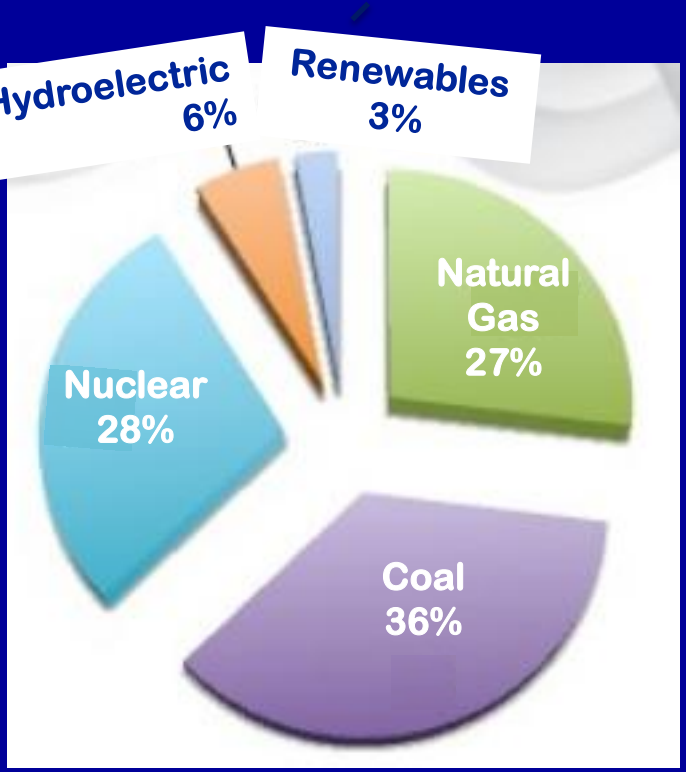
Lawrence Livermore National Laboratory



Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

WHERE IS ARIZONA on RENEWABLES?

Arizona Net Electricity Generation 2014



Arizona Renewable Energy Standard & Tariff REST

- 15% by 2025
  - ½ from residential & ½ from non-residential, non-utility installations
  - 2006 – 1.25%
  - 2007 – 1.50%
  - 2010 – 2.5%
  - 2025 – 15%

DISCUSS:
Is this an acceptable goal for AZ?
. . . A realistic goal?

Learn more about REST at: http://arizonagoessolar.org/

So what's going on SOLAR-WISE in our own STATE?

ARIZONA
Incentives/Policies for Renewables & Efficiency

see: www.dsireusa.org

DSIRE: Database of State Incentives for Renewables & Efficiency

AZ's RENEWABLE ENERGY STANDARD:

15% Renewables by 2025!

(enacted in 2006) 30% distributed!

Prior to the 2006 rules, Arizona's original Environmental Portfolio Standard required regulated utilities to generate **0.4%** of their power from renewables in 2002 , increasing to **1.1%** in 2007-2012.

"Renewable Energy Standard"

(Renewable portfolio standard - RPS)

Require UTILITIES to use or procure RENEWABLE ENERGY
(or renewable energy credits) to account for:
-- a certain % of their retail electricity sales or
-- a certain amount of generating capacity

According to a specified schedule

So what's going on SOLAR-WISE in our own STATE?

We are currently a bit ahead (+ 3%) of schedule! Most is SOLAR :

Photovoltaic (PV) (12 – 30 % efficiency)
Solar Thermal w/ storage (up to 75%)
(Plant is near Gila Bend)

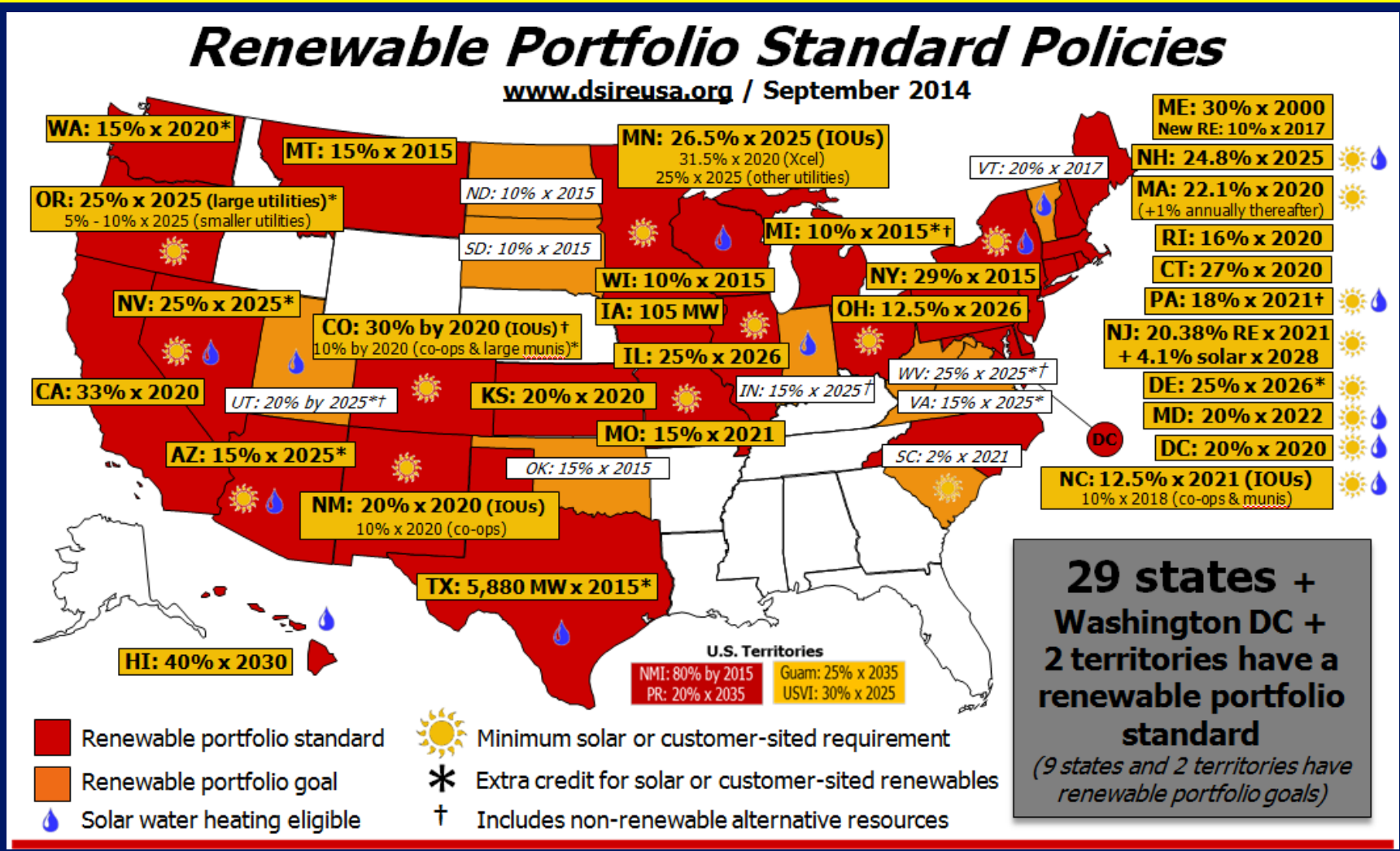
– Even though SOLAR may not be highly efficient (YET!)

SOLAR has extra benefits because **IT IS MODULAR!** (can generate electricity **CLOSE** to the point of use!)

AZ's RENEWABLE ENERGY STANDARD:

15% Renewables by 2025 ?

AZ # 2 in country on utility side, but very far behind on the consumer (US!) side! Can we do better?



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NOW . . . DISCUSS AGAIN:
Is this an acceptable goal for AZ?
. . . A realistic goal?

LINKING TO LIFE!

Arizona Corporation Commission

http://www.azcc.gov/

In AZ we VOTE for our Corporation Commission !!

And, if you are interested in seeing **SOLAR** increase in AZ . . .

THERE IS A REASON TO VOTE!!!

Arizona Wins Back Its Renewables Standard

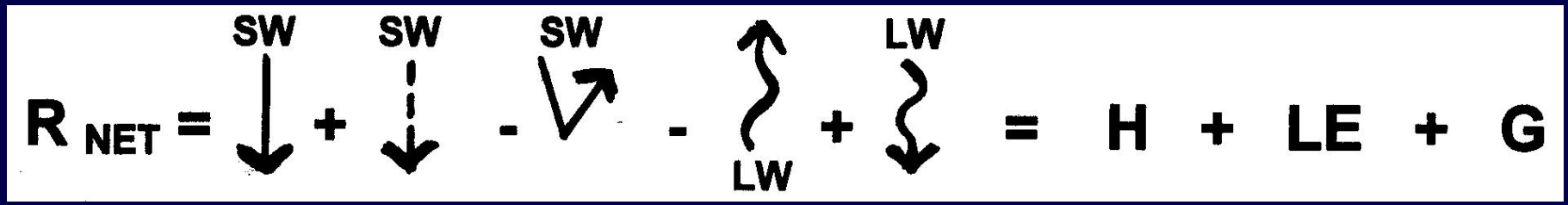
"Score a victory for an engaged citizenry."

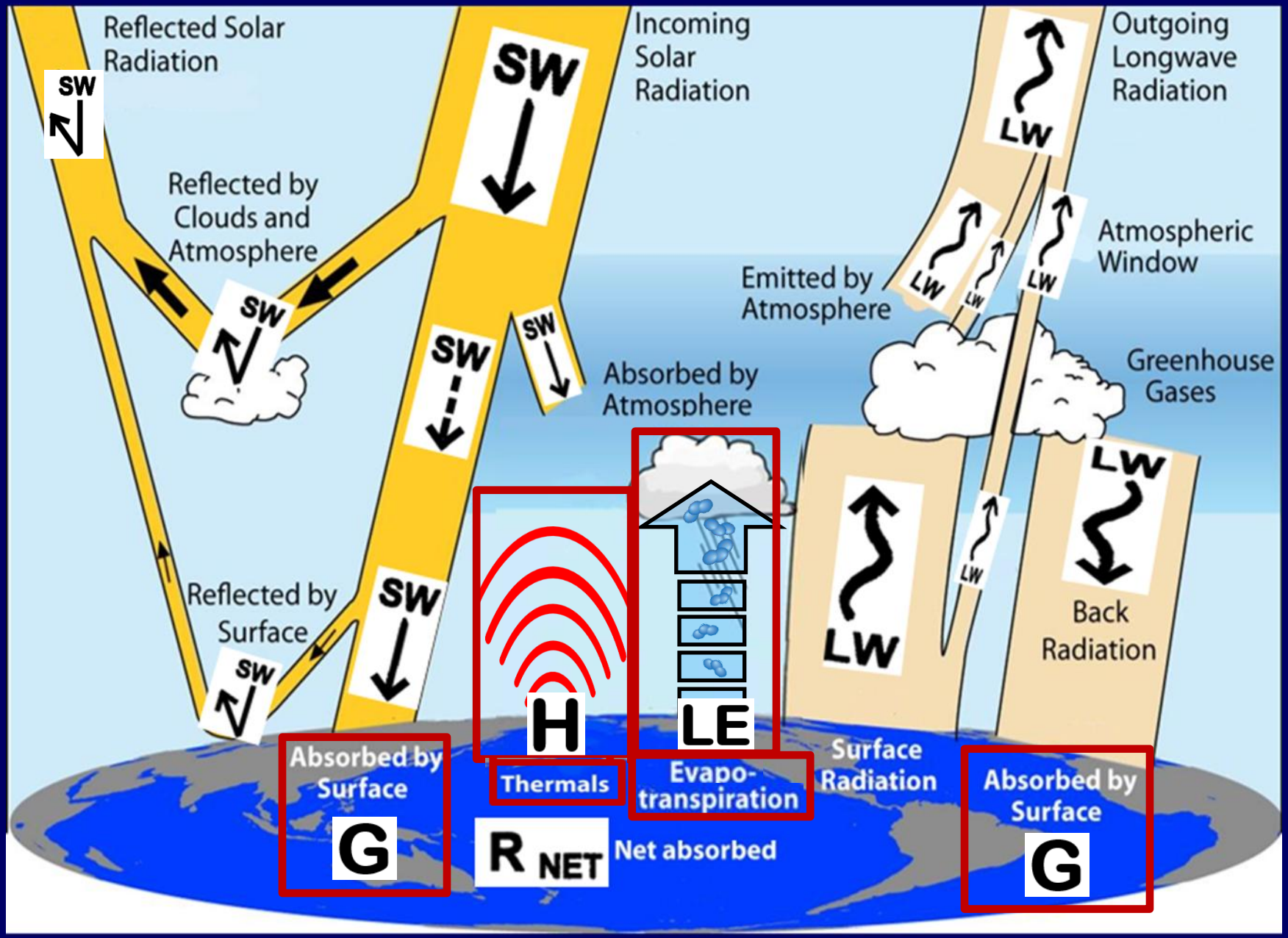
(In 2013 there was an attempt by one of the commissioners to roll back the 2006 standard!)

"Poll after poll shows Arizonans want more solar," former ACC policy advisor Nancy LaPlaca noted. That is equally true of polls about solar throughout the country. The surveys show that voters know, as LaPlaca put it, that "solar displaces fuel costs, which are in fact 'monstrous' because of the uncounted enormous health costs, dirty air and water, and climate change" that they also entail.

Topic # 8 WRAP UP:

THE EARTH'S GLOBAL ENERGY BALANCE
G-3 Assignment . . .

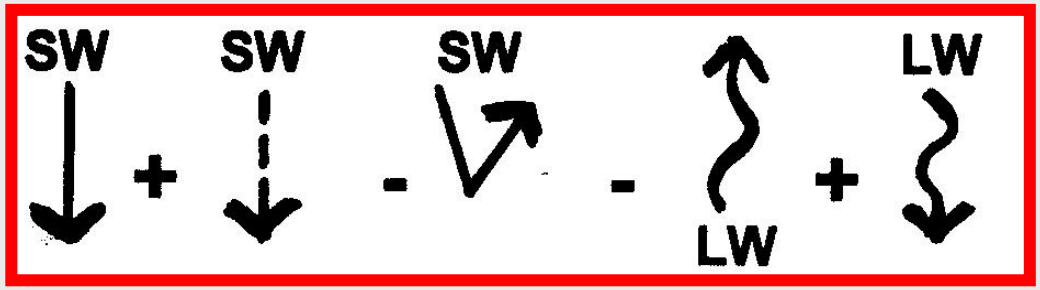


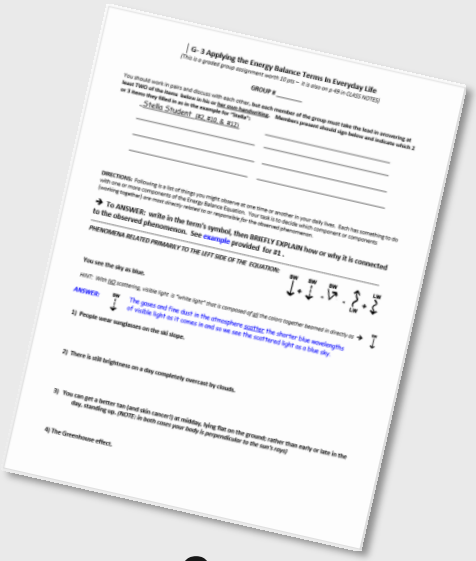

Reflected Solar Radiation
SW
Incoming Solar Radiation
SW
Outgoing Longwave Radiation
LW
Reflected by Clouds and Atmosphere
SW
SW
SW
Atmospheric Window
Emitted by Atmosphere
LW
LW
LW
Absorbed by Atmosphere
Greenhouse Gases
Reflected by Surface
SW
SW
LW
LW
LW
Back Radiation
H
LE
Absorbed by Surface
G
Thermals
Evapo-transpiration
Surface Radiation
Absorbed by Surface
G
R NET
Net absorbed

G-3 ASSIGNMENT (cont.)

Applying the Energy Balance Terms

 # 1 – #10 : Left side of equation





 # 11 - #13: Right side of equation

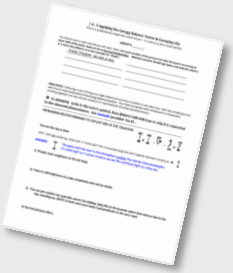
H + LE + G

&

Assignment is also on p 49 for you personal note taking

G- 3 DIRECTIONS:

- **TASK #1: Discuss and decide which SYMBOL (or symbols working together) most directly relate to #1 - #13**
- **Work in Pairs: two students work on # 1-7 and two work on # 8 - 13, then share across the table so all agree**
- **Sketch Symbol & Write Explanation on G-3 Form**
  Pass form around and "sign in" w/ #'s you did



- **TASK #2 (a) think up & sketch a new EVERYDAY LIFE example & the symbol(s) involved**
  (b) WRITE a short explanation on Whiteboard; select student to REPORT for a GROUP BONUS
  (c) Put GROUP # on boards, take photos, email to Dr H

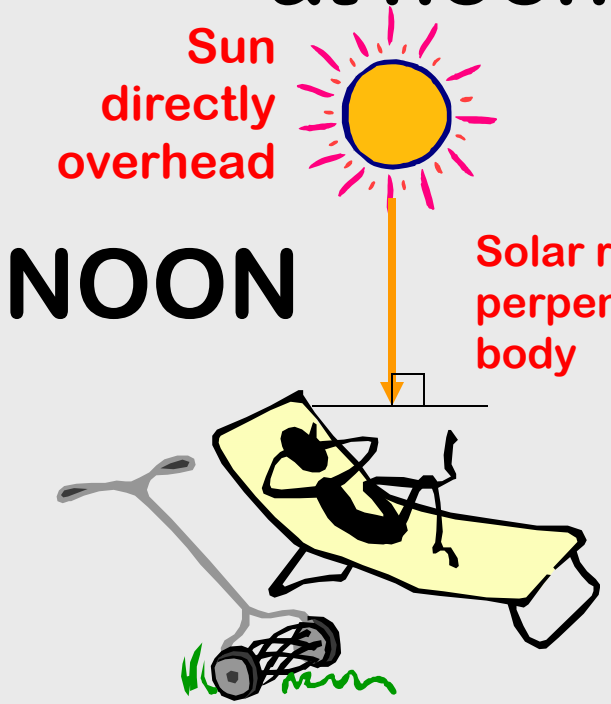
- **TASK #3: Work together on pp 50 – 51 in CLASS NOTES**

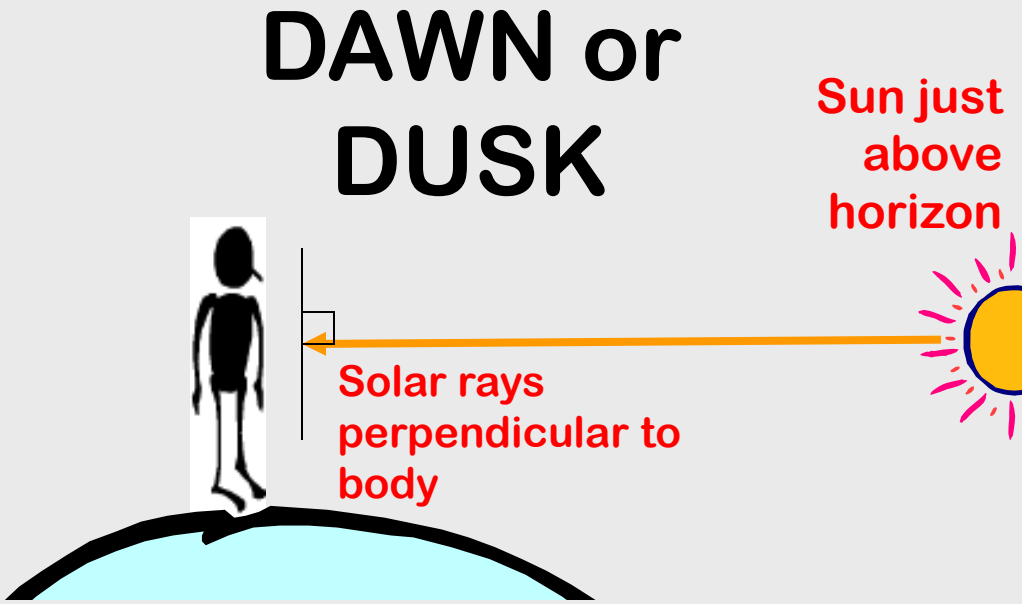
Practice:
blue skies

1. Sunglasses while skiing

2. Bright even though cloudy

3. More intense solar radiation (tan /skin damage, etc.) at noon vs. dawn or dusk



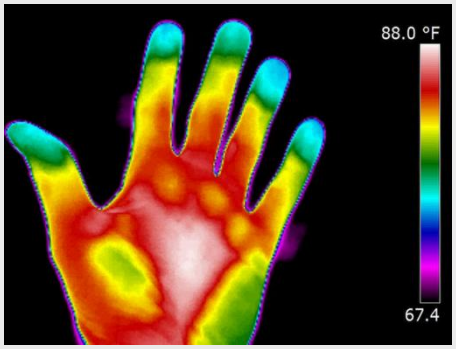


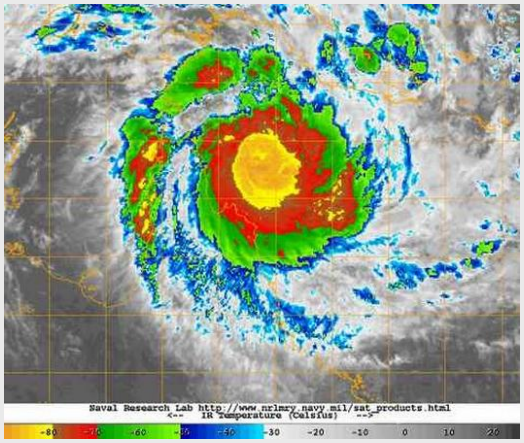
4. The Greenhouse Effect

(hint 2 symbols together)

5. Red sunsets

6. Infrared Imagery





7. Shadow on sunny day

8. Rainbow

9. Black streaks

10. Parking on blacktop on a sunny day

11. Hot air balloon

12. Pigs cooling off in the mud

13. Evaporative coolers work best in the desert

Hot DRY AIR goes IN & is forced thru WET pads

COOL AIR enters house & cools it !

G-3 ASSIGNMENT (10 pts)

Applying the Energy Balance Terms

REMEMBER . . . Discuss the answers together, but EACH GROUP MEMBER must take the lead in answering 2- 4 questions (in your own handwriting)

Pass the form around & when you sign in, list the # or #'s you did:

Stella Student (#2, #10, & #12) _____

WHEN YOUR G-3 FORM IS COMPLETED, WORK TOGETHER ON pp 50 & 51 in CLASS NOTES

TIME TO WRAP UP FOR TODAY!

G-3 ASSIGNMENT (10 pts)

Applying the Energy Balance Terms

Stella Student (#2, #10, & #12) _____

Don't forget to SIGN IN with the #'s you wrote up!