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I. Energy Saving Lamps (CFL) replacing the Bulb in the Living Room

Step-wise description and assessment of the machine is as follows:

STEP	DESCRIPTION OF STEP/EVENT
1.	A 60 W incandescent lamp is replaced by a 15W CFL. The replaced 60W ICL when dropped bounces on a surface and rebounds.
2.	The rebounding ball activates a “See-saw Lever”.
3.	The upward moving end of the see-saw lever pulls up a lock through a groove, freeing a ball that was held up.
4.	The rolling ball strikes one end of a see-saw lever, makes an alarm and the forward movement of the other end moves a “Plunger” tied to it through a rope.
5.	The downward movement of the Plunger through the “barrel” displaces the liquid contained in the barrel causing it to spray out through a nozzle.
6.	The impact of the spraying liquid on a bowl, activates a Scissor linkage that moves up a “Hand” connected to it at one end.
7.	The upward movement of the Hand releases a spring held cantilever that ultimately Opens the jaw of a V-linkage.
8.	The opening of the V-linkage frees a round weight that falls down
9.	The impact of the falling weight on the see-saw lever causes the other end to move up.
10.	The upward movement of the see-saw pops up the ball held in this end.
11.	The popped ball falling on one end of a see-saw lever causes a scissor to close.
12.	The closing of the scissor cuts a thread that held a gas filled balloon by a weight.
13.	The cutting of the thread causes the weight attached to the bottom of the thread to fall down and frees the gas filled balloon.
14.	The upward movement of the freed balloon strikes one end of a see-saw lever that causes a ball placed at the other end of it to fall on a sliding surface.
15.	The ball rolling through the sliding surface strikes a pad which is attached to a gear assembly that tilts a Jug connected to it.
16.	The tilting of the jug causes the water contained in it to fall.
17.	The water falls on a cup placed below, causing the Hand holding the cup to move down.
18.	The downward movement of the hand holding the cup moves activates a gear train that pushes a Hand, which activates the opening of a lever, thereby freeing a rope that holds a heavy ball, causing it to fall.
19.	The ball falling on a see-saw lever activates a series of levers, moving down a stopper connected to one end, from its locking position in a groove of a sliding surface.
20.	The downward movement of the stopper frees a ball that rolls down the surface, passes through a

	funneled pipe and opens the door of a box “Save Energy”, thereby freeing a rabbit from the box.
21.	The freed rabbit runs over a belt conveyor, the movement of which activates the rollers below, causing the “Winder” attached to it to pull up a rope that opens the cover of a box, from which a Hand moves out.
22.	The movement of the Hand outwards, impacts a See-saw lever that activates a Hammer.
23.	The movement of the Hammer breaks an incandescent bulb, causing a round weight that it held to in tension, to fall.
24.	The falling round weight activates a “Gear train” that frees a Hook, which moves away from its locking position over a sliding lever.
25.	The upward movement of the sliding lever activates the movement of a “Hand” attached to it through a series of linkages.
26.	The upward movement of the hand pushes up a “U-Channel”, causing a ball in the U-channel to fall down.
27.	The ball falling on one end of a See-saw lever moves a match stick connected at the other end, downwards.
28.	The downward movement of the matchstick, strikes on a pad, catches a flame and lights up a candle placed below.
29.	The impact of the match stick on the pad that is supported by a spring, pushes it backwards, pushing down a ball that rolls down through a U-channel and falls on one end of a see-saw, which is placed on a platform made up of 2 parts, one of which can open downwards.
30.	The falling ball activates a series of “Gear trains” that finally causes the moving part of the platform to lose its bottom support, thereby opening downwards. The bottle kept over this moving piece of platform falls down, spraying out the contents and the thread that is tied to the neck of the bottle moves down, through a series of pulleys, pulling up a Hook
31.	The upward movement of the Hook opens up the “Announcement” proclaiming the Need for The world to embrace ENERGY MODESTY AND EFFICIECNY, depicted through the Life cycle of evolution of the Lighting, as rightly shown in this activity wherein the Incandescent bulb is replaced by CFL.

II. Answers to the 3 Questions are as below:

1	**An incandescent light “bulb: converts only ?% of the energy in Coal provided to a power plant to generate a useful energy output. Estimate how large is ? in percent** **Ans:** The efficiency in conversion of Coal to Electricity at point of Use i.e. electricity consumed by incandescent bulb, is about 29%.(*Note: Steps for this calculation given in Answer to Question#3) Further, out of the Electricity input to an incandescent lamp, only 10% of it is converted to light. The remaining 90% is wasted as heat. Therefore the overall Efficiency ? % is 0.29*0.10 = 0.029 = **2.9 %**. **The estimation is that incandescent bulb converts only about 3% of the energy in Coal to generate useful energy output.**
2	**What is the useful energy output of a CFL** **Ans:** **“Useful energy output” of a lamp is the energy in terms actual light it emits**. Every lamp/bulb converts a only a part of its input energy to the form of light energy that is visible to the human eye. The rest is mostly lost as heat energy. In some cases, some of it is also converted to electromagnetic waves outside the visible spectrum. The light energy is expressed in lumens.

	"Useful energy output" of a CFL is typically in the range of 400-1500 lumens (For 8W-24W respectively) i.e. in the range of 50-60 lumens/Watt. In purely energy terms, while an incandescent light bulb converts 10% of its input energy to Useful light and 90% is lost as heat, in a CFL, nearly 40% of its input energy is converted to light and only 60% is lost as heat. The statement comparing Useful Energy Output of a 60W Incandescent Lamp with its equivalent 15W CFKL is shown below: **% Converted to light** | **% Lost as Heat** | **Lamp rating (Input Power in Watts)** | **Useful Energy Output (in Watts)** | **Heat Loss (in Watts)** ILB (Incandescent Light Bulb) | 10 | 90 | 60 | **600** | **5400** CFL (Compact Flourescent Lamp) | 40 | 40 | 15 | **600** | **600** * The minimum output lumens in both cases is about 660 lumens
3	**Where is the energy lost on its way from Coal to electricity consumed by the CFL** **Ans:** The Losses from the Coal to the electricity consumed by the CFL are as per the following Major sequence of steps: 1. In the Power Generating Station where there is Heat Losses in Boiler during conversion of Coal to Steam and there is Loss in the Steam-Turbine Generator when this steam is converted to Electricity. The Overall efficiency of the typical Thermal Power Station is approximately 35%. Therefore the loss is about 65%. 2. The Generated Power is stepped up to EHV (400/800 kV) to enable transmission over large distances. The loss in EHV Step-up and transmission here is about 1.5% (Efficiency 98.5%) 3. This is converted to 220 kV/132 kV/66 kV etc. in HV Substations for HV transmission and sub-transmission. The loss in this step is about 5%. 4. The Distribution Stations Step down to 11 kV/ 33 kV. The Transformer losses and distribution loss is about 5%.(Efficiency 95%). 5. The secondary Distribution converts to LV levels is about 5%.(Efficiency 95%). 6. Secondary LV Distribution Loss from Distribution Transformers to Home is about 0.5% (Point of Use-CFL). (Efficiency 98.5%). **The overall efficiency up to the point of Use i.e. electricity consumed by CFL, is 0.35*0.985*.95*.95*.95*0.995 = 29% , or, the Overall Energy loss is 71%.**