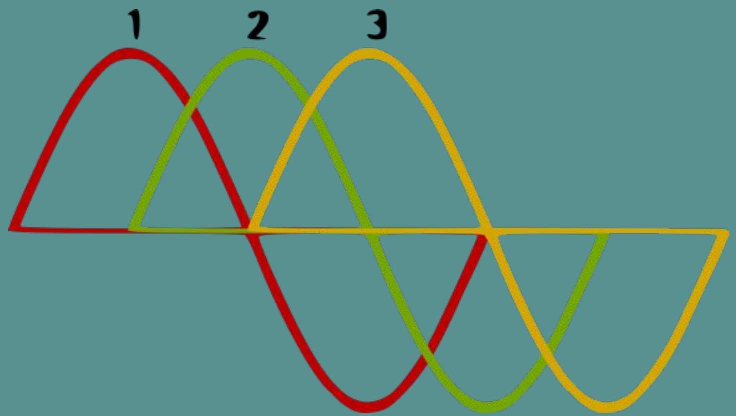
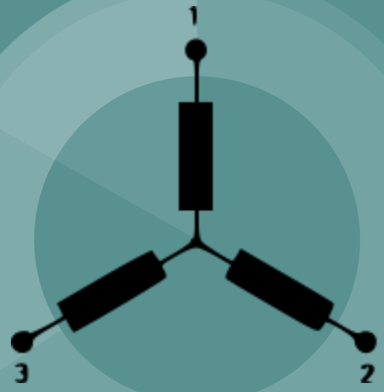
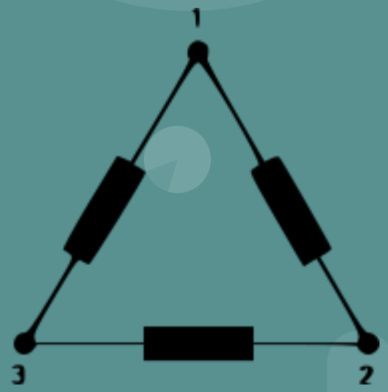
Making Sense of Delta & Wye

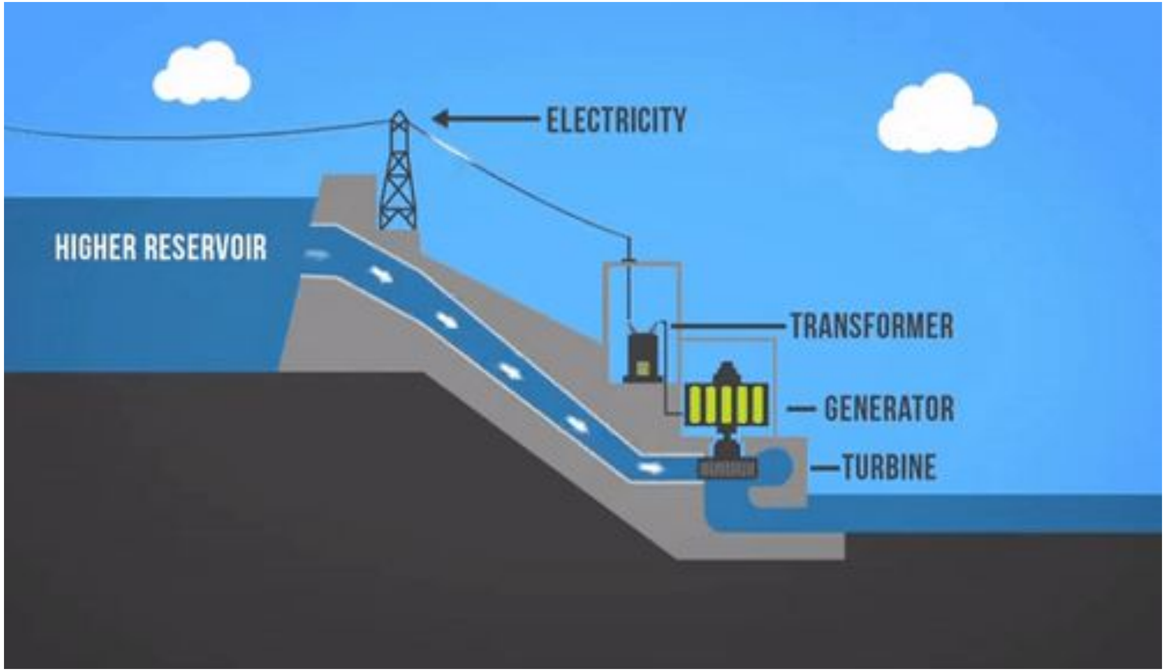
By: Drew Matthews



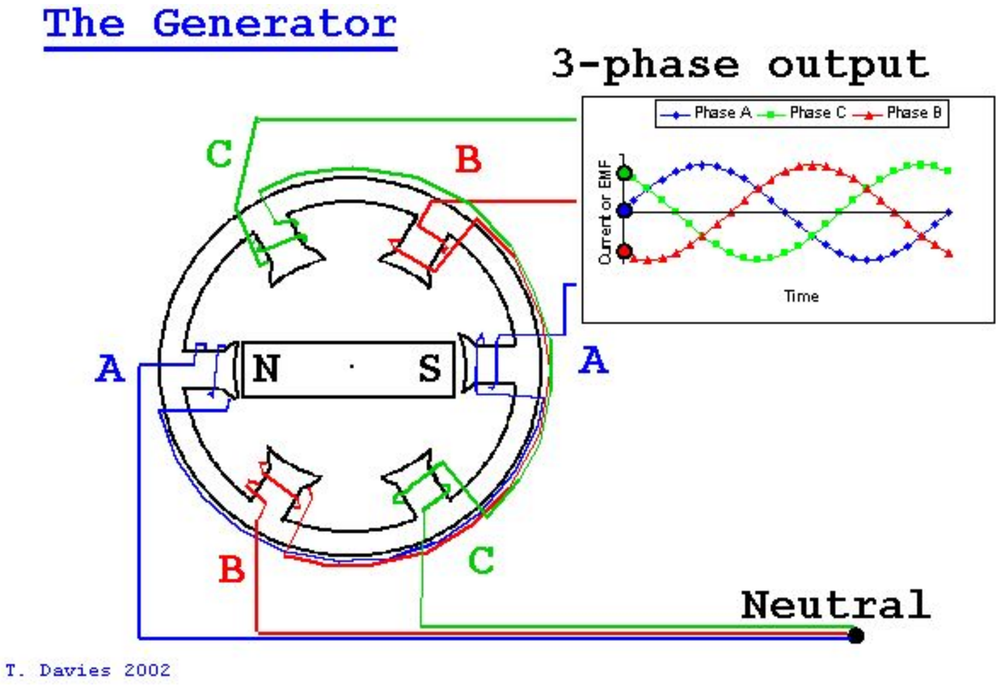




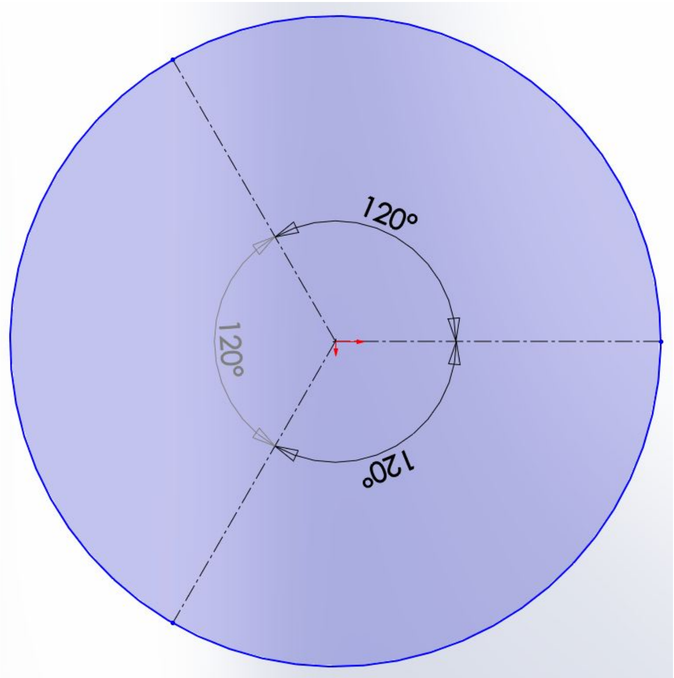
Where Does Power Come From?

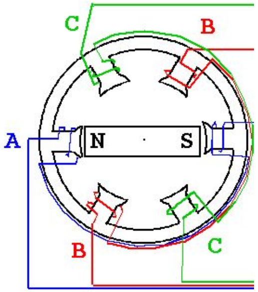


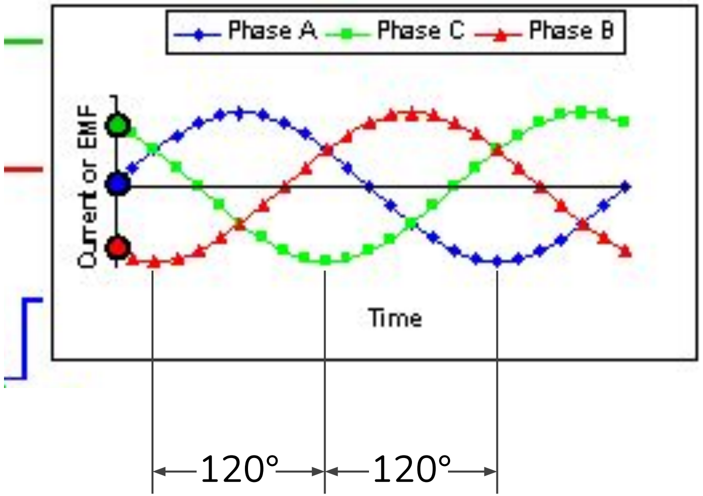
How are the Three Phases Generated?



Phase


120°
120°
120°

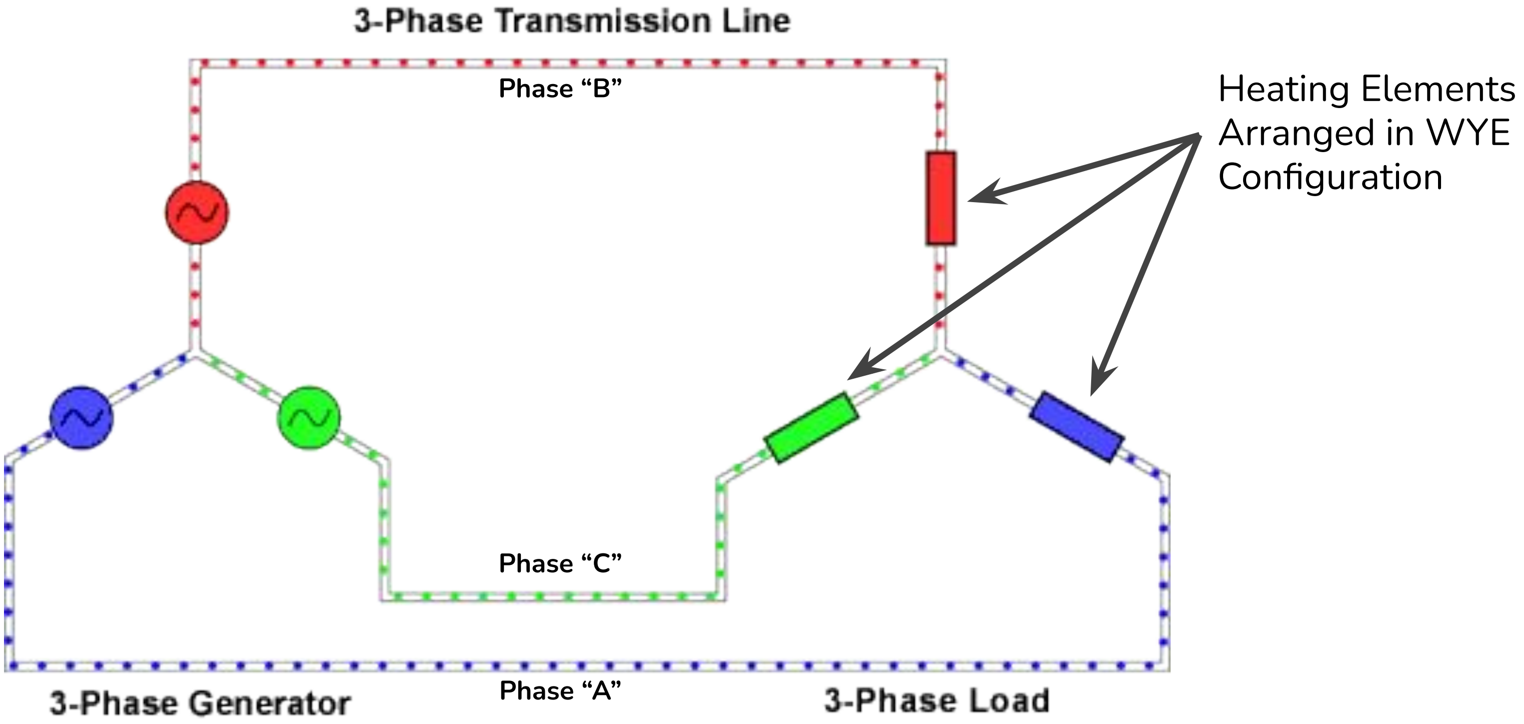

C
B
A
N
S
B
C


Phase A
Phase C
Phase B
Current or EMF
Time
120°
120°

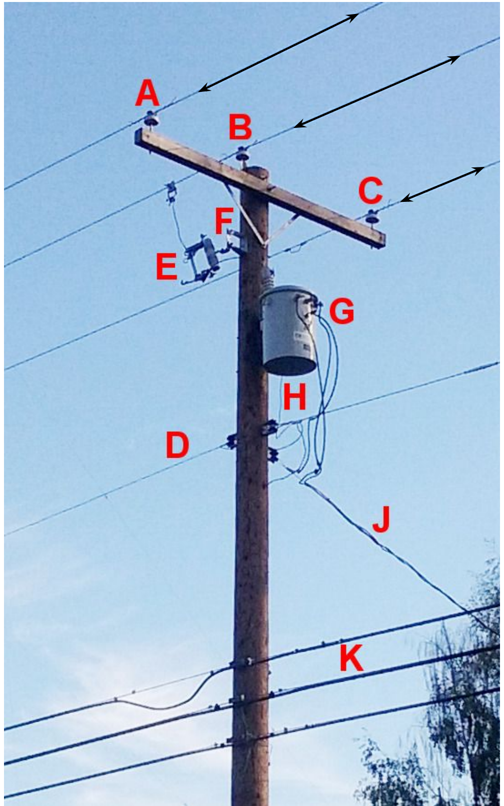
Alternating Current (AC) Energy Flow

In North America the Energy Changes Directions 60 Times Per Second (60 Hz)

This is Why it is called “Alternating Current”



How It’s Transmitted



Typical North American utility pole, showing hardware for a residential 240/120 V split-phase service drop:

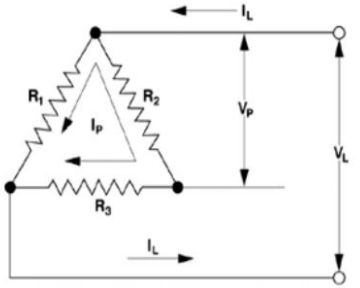
(*A,B,C*) 3-phase primary distribution wires
(*D*) neutral wire
(*E*) fuse cutout
(*F*) lightning arrestor
(*G*) single phase distribution transformer
(*H*) ground wire to transformer case
(*J*) "triplex" service drop cable carries secondary current to customer
(*K*) telephone and cable television cables

Calculating the Difference

3-Phase Delta (Δ)

A Delta configuration is a circuit in which three loads are connected in a "triangle" with each load representing a side of the triangle.

Delta is typically used up to 277VAC



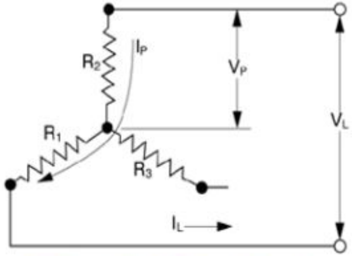
3-Phase Delta (Balanced Load)

$I_P = I_L/1.73$
$V_P = V_L$
$W_{DELTA} = 3(V_L^2)/R$
$W_{DELTA} = 1.73\, V_L I_L$

Figure 7 – 3-Phase Delta

3-Phase Wye

A Wye configuration is a circuit in which three loads are connected in a Y with each load representing a leg of the Y. Figure 8 illustrates how a basic Wye circuit is laid out.



3-Phase Wye (Balanced Load)

$I_P = I_L$
$V_P = V_L/1.73$
$W_{WYE} = V_L^2/R = 3(V_P^2)/R$
$W_{WYE} = 1.73\, V_L I_L$

WYE is typically used above 277VAC

Delta / WYE Formulas - HERE

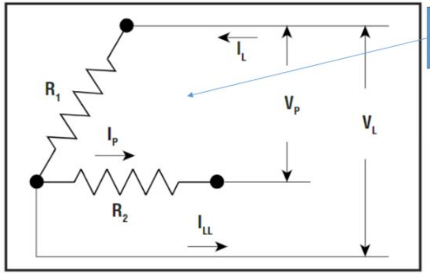
How Output Changes
"Broken Coil Delta" vs "Broken Line Delta"

"Broken Coil DELTA"

Unbroken Heater Details:
18kW Heater
480V 3Phase
With 3 - 6kW Coils
21.65 Heater Amps
21.65 Amps Per Leg
38.4 Ω Per Coil (with no temp factor)
25.6 Total Heater Ω

Heater Output Watts:
12000 Watts

3Ø Open Delta



This Represents a Broken Coil which would be here.

$V_P = V_L$ $\quad V_L = V_P$

$W_T = 2V_L \times I_L$ $\quad W_T = 2\,(V_L^2 \div R_1)$

$I_P = I_L$ $\quad I_L = I_P$

$W_C = 2V_P \times I_P$ $\quad I_{LL} = 1.73 \times I_P$

$$2 \cdot \left(\frac{480^2}{38.4}\right) = 12000$$

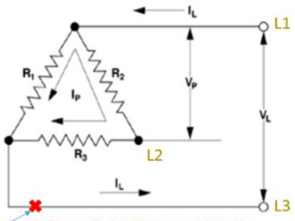
Failure of an element in a three (3) element Delta circuit will reduce the wattage output by 33%

"Broken Line DELTA"

3-Phase Delta (Δ)

A Delta configuration is a circuit in which three loads are connected in a "triangle" with each load representing a side of the triangle.

Unbroken Heater Details:
18kW Heater
480V 3Phase
With 3 - 6kW Coils
21.65 Heater Amps
21.65 Amps Per Leg
38.4 Ω Per Coil (with no temp factor)
25.6 Total Heater Ω



Broken Line

3-Phase Delta (Balanced Load)

$I_P = I_L/1.73$
$V_P = V_L$
$W_{DELTA} = 3(V_L^2)/R$
$W_{DELTA} = 1.73\,V_L I_L$

Figure 7 – 3-Phase Delta

12.5 Amps through each coil when unbroken

From L1-L2:
Resistance = R2 = 38.4Ω
Current = 12.5 Amps
Wattage = 6000 Watts
&
Resistance = R1+R3 = 76.8Ω
Current = 6.25 Amps
Wattage = 3000 Watts

Heater Output Watts:
6000+3000 = 9000 Watts

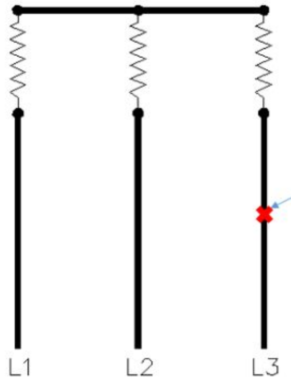
How Output Changes
“Broken Coil WYE” & “Broken Line WYE”

“Broken Line WYE”

“Broken Coil WYE”

These are the same scenario on a 3-Wire WYE.

Unbroken Heater Details:
18kW Heater
480V 3Phase
With 3 - 6kW Coils
21.65 Heater Amps
21.65 Amps Per Leg
12.79 Ω Per Coil (with no temp factor)
25.6 Total Heater Ω



Broken Line

EACH COIL = 12.79 Ω
25.58 Ω FOR 2 IN SERIES

480V / 25.58 Ω = 18.8 Amps
18.8 A * 480V = 9024 Watts

Heater Output Watts:
9024 Watts

Conclusion

Each Type Of Wiring Configuration (Delta And Wye) Have Their Own Unique Benefits. Now That We Know Their Differences We Can Use Their Benefits To Our Advantage In Order To Create An Optimal Heater Design.