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EE101 TERM PROJECT 3

FOPS Wind Turbine System

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PROBLEM STATEMENT

FOPS, one of the country's leading wind energy developers, wants to deploy a 200 MW wind farm to the rolling hills located at the northwest of the Metropolis. FOPS company hired me as a power engineer to plan the lowest costing design to implement the wind farm to the present city plan. The wind turbines which would be installed were Type 3 DFAG turbines with an output of 200 MW, a voltage setpoint of 1.05 per unit, and with reactive power limits of ±100 MVAr. For reliability reasons turbines need to be fed into two separate interconnection substations and to be in line with the FOPS tradition, the interconnection points will be at 69 kV. Three different substations are available for this project are PAI(69), PETE(69) and DEMAR(69). For these transmissions to be made there are three different types of conductors named CROW, CONDOR and ROOK that can be used, and all the different conductors have different characteristics.

Current Situation

For the current situation, the system does not have the wind turbine and the power loss of the system is 10.71 MW. I can calculate the price of the losses before wind turbine is added to the existing system.

Data

***Table 1**, Calculating the Old System Losses Cost*

Table 1 : calculating old system lose	without wind turbine
Number of hours in 5 years	43800.00
Price for losses ($/MWh)	$ 50.00
Power Losses (MW)	10.71
Energy Losses (MWh)	469,098.00
System Losses Cost ($)	$ 23,454,900.00

As shown in the Table 1, we have how many hours in 5 years is 43,800, price for losses in unit MWh is in dollars is 50 dollars, power losses in unit MW is 10.71 MW, energy losses in unit MWh is 469,098 MWh and total system losses cost in dollars 23,454,900 dollars for one hour and 2,190,000.00 dollars for 5 years.

Table 2 *Milages Between stations and Wind Turbine*

Substations	Milage between
FOPS to PAI	20
FOPS to PETE	25
FOPS to DEMAR	30

As shown in the Table 2, we have distance between wind turbine and stations in unit mile. FOPS (wind turbine) to PAI is 20 miles, FOPS to PETE is 25 miles and FOPS to DEMAR is 30 miles.

Table 3 *data of conductors type, costs, current rates, resistances and inductive resistances*

Conductor Type	Conductor Cost	Current Rate (amp)	Resistance (ohms per conductor per mile)	Inductive Resistance (ohms per conductor per mile)
Rook	$200,000/mi	770	0,1678	0,414
Crow	$220,000/mi	830	0,1472	0,407
Condor	$240,000/mi	900	0,1358	0,401

As shown in Table 3, we have 3 different conductor type and all their costs, current rates, resistances and inductive resistances are shown in Table 3.

Experiments Starts from the next page.

In the experiences I did not add the fix cost, I will add that in the conclusion with best scenario.

Experiment 10 PETE – ROOK, DEMAR – ROOK (NOT WORKING - WORST CASE)

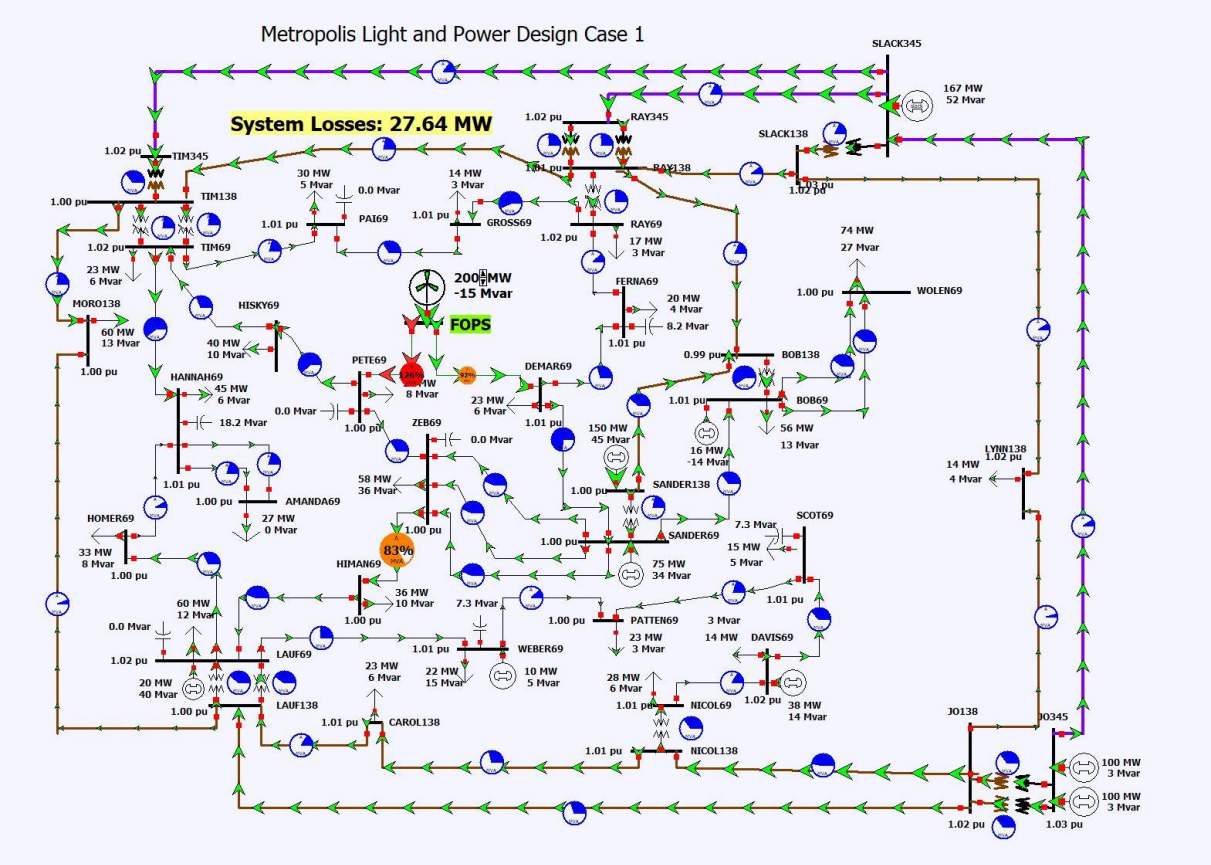

Figure 1 POPS connected to PETE with ROOK and connected to DEMAR with ROOK conductors.

EXP NO	FOPS TO ----	Conductor Type	Conductor Cost	milage between	Status	System Loss	Total System Loss Cost in 5 years
EXP 10	PETE	ROOK	$200,000/mi	25	NOT WORKING	27.64	$ 60,531,600.00
	DEMAR	ROOK	$200,000/mi	30			

Table 4 all the data from Figure 1

That Experiment has worst stats from all the experiments so far.

As shown in Figure 1. PETE is connected to POPS with ROOK conductor and DEMAR is connected to POPS with ROOK conductor. Experiment 10 has highest system loss (27.64 MW that means 16,93 more MW lose in system) and system loss cost 60,531,600.00 dollars in 5 years from all in the experiences.

Even though ROOK conductor which connected to DEMAR is working on the limits with 92% on ROOK conductor, ROOK conductor which connected to PETE is not enough to carry that electric and that conductor is overloading with 126%, that means that conductor is going to burn down by that the system will not work.

So that we cannot use that connection for our solution.

Experiment 8 PETE – CONDOR, PAI – CROW Connections (NOT WORKING - BEST CASE)

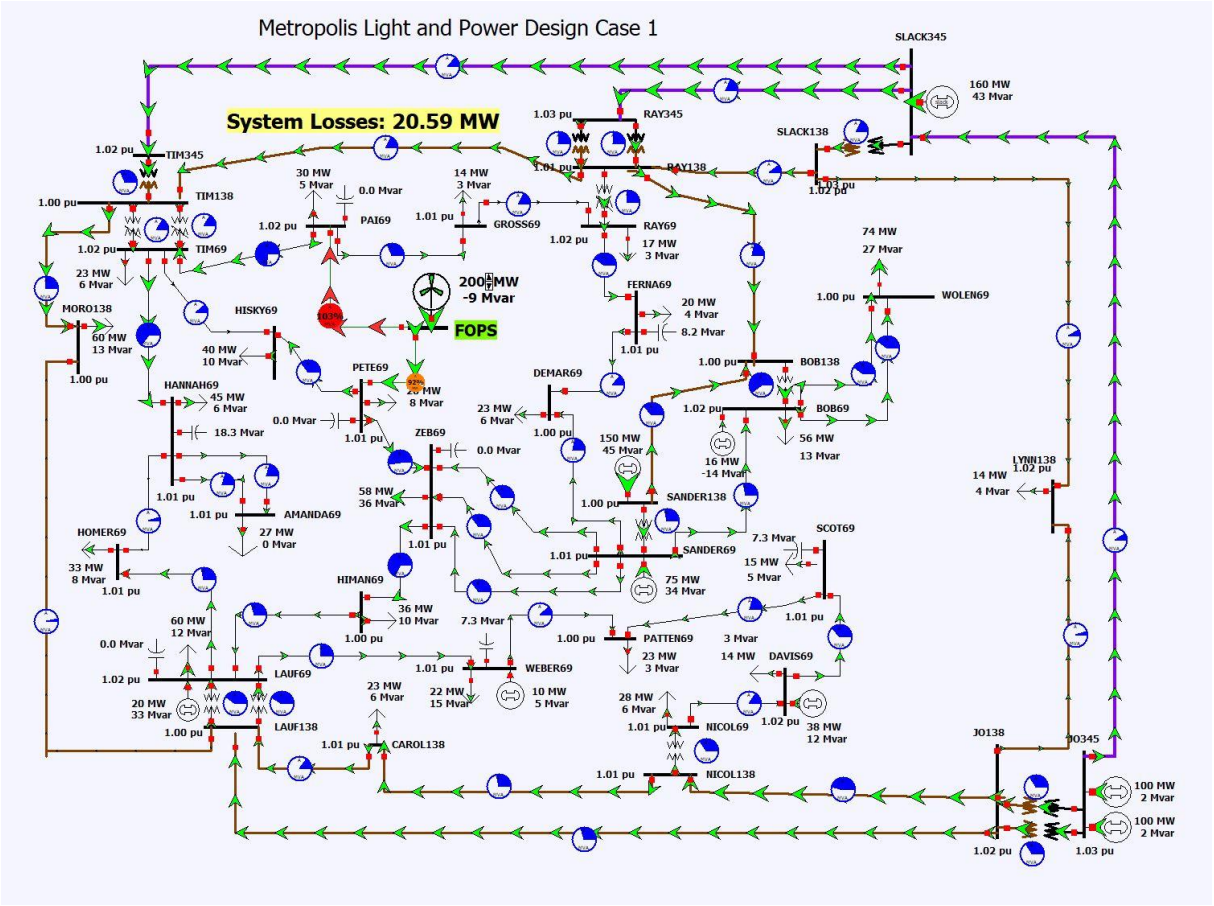

Figure 2 FOPS connected to PETE with CONDOR and connected to PAI with CROW conductors.

EXP NO	FOPS TO ----	Conductor Type	Conductor Cost	milage between	Status	System Loss	Total System Loss Cost in 5 years
EXP 8	PETE	CONDOR	$240,000/mi	25	NOT WORKING	20.59	$ 45,092,100.00
	PAI	CROW	$220,000/mi	20			

Table 5 all the data from Figure 2

That Experiment has best stats from all the experiments in not working systems so far.

As shown in Figure 2. PETE is connected to POPS with CONDOR conductor and PAI is connected to POPS with CROW conductor. Experiment 8 the is best case in not-working cases, in that case we have 2nd lowest system loss (20.59 MW that means 9,88 more MW lose in system) in all cases and lowest system loss in not-working cases. Also Experiment 8 has 2nd lowest Total System Loss Cost in all experiments 45,092,100.00 dollars in 5 years.

Even though CONDOR conductor which connected to PETE is working on the limits with 92% load on conductor, CROW conductor which connected to PAI is not enough to carry that electric and that conductor is overloading with rate of 102%, that means that conductor is going to burn down by that the system will not work.

Although we got second best results from all experiments with Experiment 8 we cannot use that connection system with our project because of the overload on the PAI connection.

Experiment 6 PETE – CROW, PAI – CONDOR

(WORKING – SECOND BEST CASE)

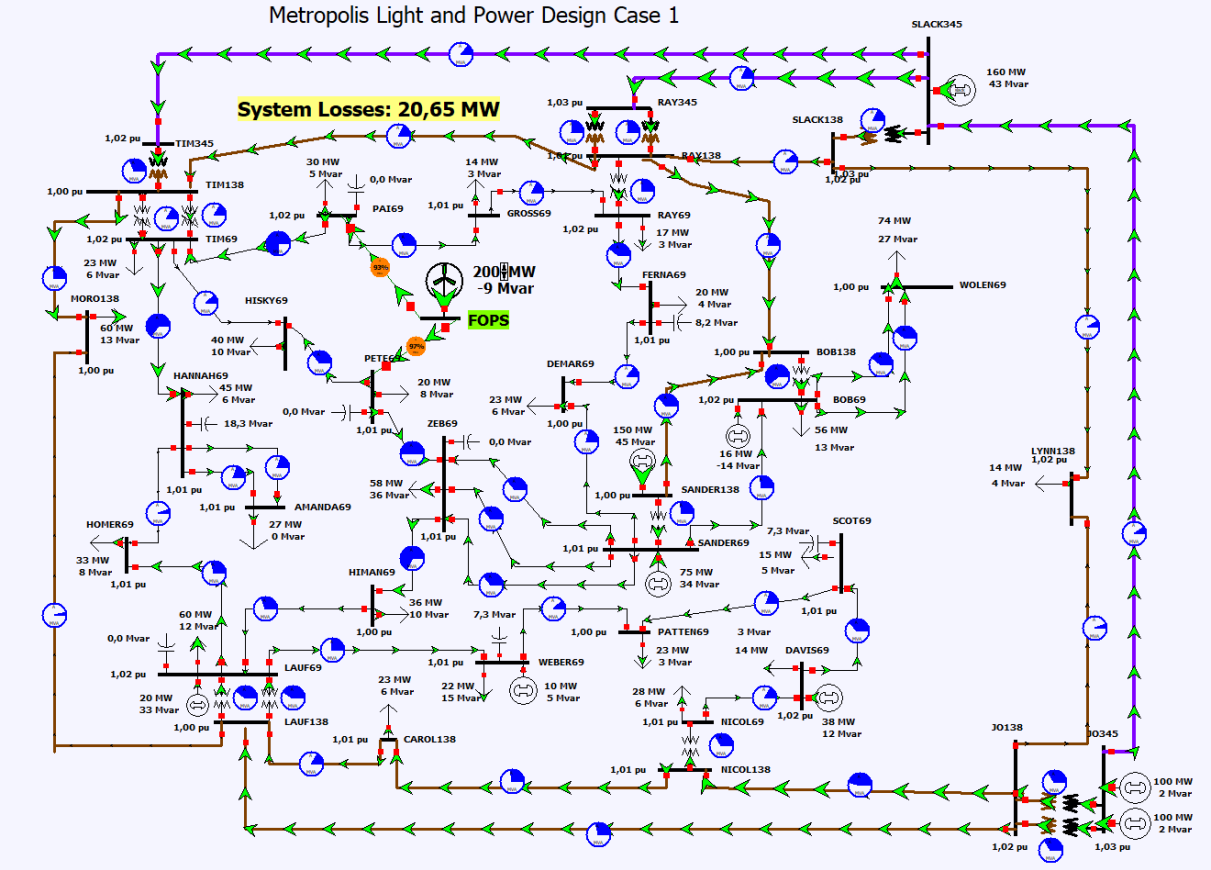

Figure 3 FOPS connected to PETE with crow and connected to PAI with CONDOR conductors.

EXP NO	FOPS TO ----	Conductor Type	Conductor Cost	milage between	Status	System Loss	Total System Loss Cost in 5 years
EXP 6	PETE	CROW	$220,000/mi	25	WORKING	20.65	$ 45,223,500.00
	PAI	CONDOR	$240,000/mi	20			

Table 6 all the data from Figure 2

In that case we have got second best of the working cases for our experiences.

As shown in Figure 3. PETE is connected to POPS with CROW conductor and PAI is connected to POPS with CONDOR conductor. Experiment 6 the is second best case in working cases, in that case we have 3rd lowest system loss (20,65 MW that means 9,94 more MW lose in system) in all cases and but if we consider that system connection is working that case is second best condition in terms of system loss. Also Experiment 6 has 3rd lowest Total System Loss Cost in all experiments with 45,223,500.00 dollars in 5 years and makes cable costs are 5,500,000.00 dollars for PETE connection with CROW conductor and 4,800,000.00 dollars for PAI connection with CONDOR conductor and total cost is 54,840,900.00 dollars in 5 years.

Even though that system works in our experiments, that is not best case for our system in terms of money and system lose.

Experiment 9 PETE – CONDOR, PAI – CONDOR (WORKING – BEST CASE)

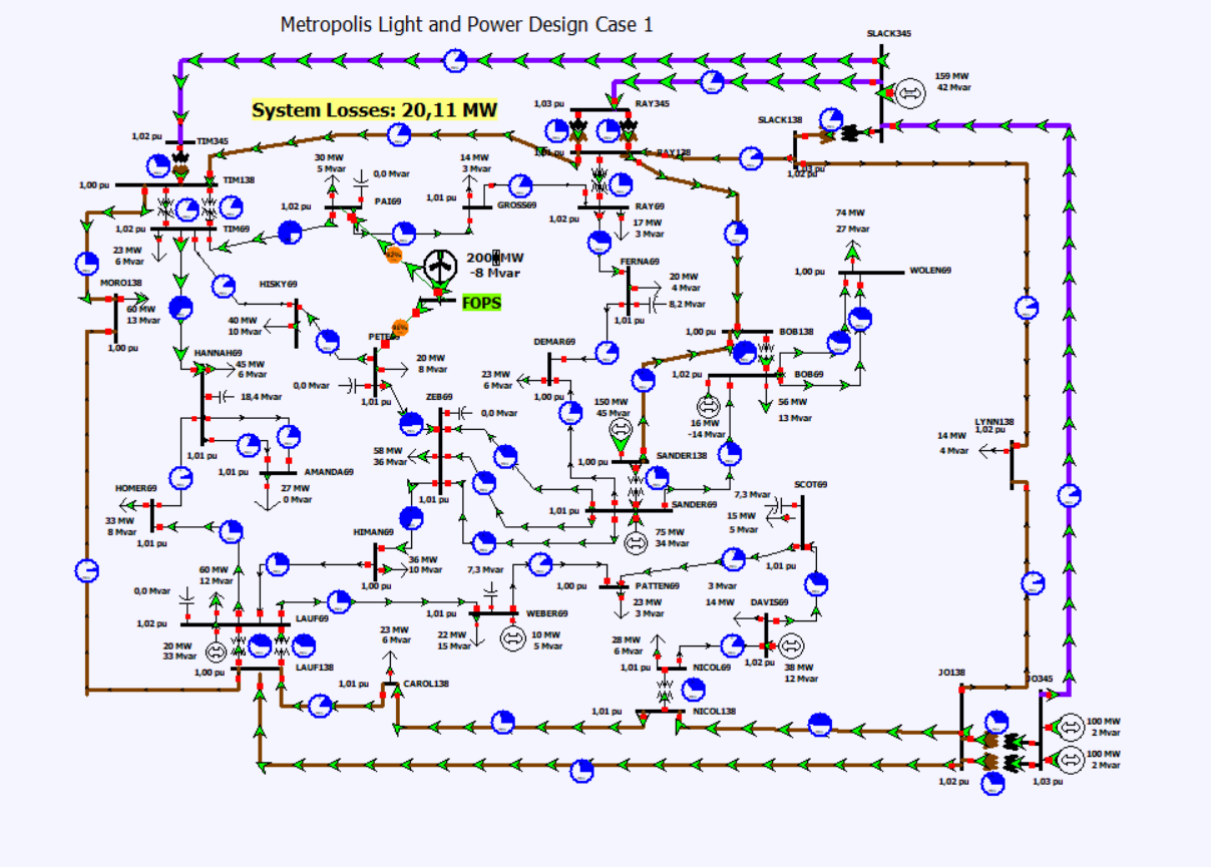

Figure 4 FOPS connected to PETE with CONDOR and connected to PAI with CONDOR conductors.

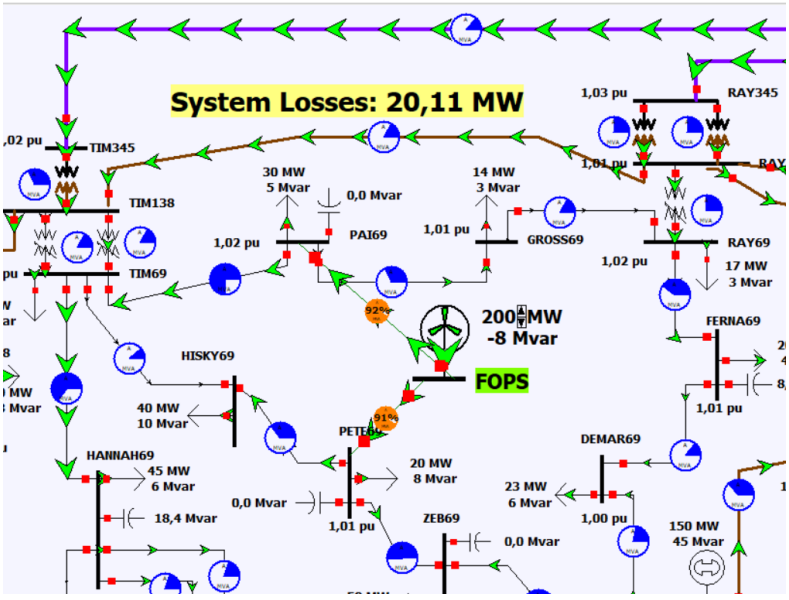

Figure 5 zoomed version of Figure 4

EXP NO	FOPS TO ----	Conductor Type	Conductor Cost	milage between	Status	System Loss	Total System Loss Cost in 5 years
EXP 9	PETE	CONDOR	$240,000/mi	25	WORKING	20.11	$ 44,040,900.00
	PAI	CONDOR	$240,000/mi	20			

Table 7 all the data from Figure 4

In Experiment 9 we have best case so far from all experiments.

In that case POPS connected to PETE with CONDOR conductor and POPS connected to PAI with CONDOR conductor. As we can see both CONDOR conductors are working around 91%, so that we can say that two connection is usable for additional wind turbine system.

We have 20,11 MW system lose with both CONDOR conductors instead of 10,71 MW which was the beginning case that means additional 9,40 MW system lose from wind turbine system. In that case we will use CONDOR conductors on 25 miles for PETE station and 20 miles for PAI stations with 240,000.00 dollars per mile for each conductor. That makes cable costs are 6,000,000.00 dollars for PETE connection with CONDOR conductor and 4,800,000.00 dollars for PAI connection with CONDOR conductor and total cost is 54,840,900.00 dollars in 5 years.

Experiment 9 is best scenario from all experiments in terms of money and system lose.

So that I recommend to use the connection system which I used in Experiment 9.

Budgetary Calculations

If we use same system as I have already showed in Experiment 9, which is

Connection between PETE with CONDOR conductors in 25 miles and connection between PAI with CONDOR conductors in 25 miles.

We will have to pay 240,000.00 dollars for each mile. That will make 6,000,000.00 dollars for PETE connection with CONDOR conductor and 4,800,000.00 dollars for PAI connection with CONDOR conductor. Total cost of conductors will be **10,800,000.00 dollars** for our system as shown in the Table 8 below.

Table 8 *Cost of Cables for Experiment 9*

	EXP 9	
	FOPS TO ---	FOPS TO ---
	PETE	PAI
CONDUCTOR	CONDOR	CONDOR
CONDUCTOR COST	$ 240,000.00	$ 240,000.00
MILAGE TO FOPS	25	20
CABLE COST	$ 6,000,000.00	$ 4,800,000.00
TOTAL CABLE COST	10800000.00	

By the connection we will have 20.11 MW system lose. We have 43,800.00 hours in 5 years so it will make 880,818.00 MWh lose. Every hour costs 50 dollars, that is default, if we multiply 50 and 880,818.00 it will make **44.040.900 dollars in 5 years** as shown in the Table below

Number of hours in 5 years	43800.00
Price for losses ($/MWh)	$ 50.00
Power Losses (MW)	20.11
Energy Losses (MWh)	880,818.00
System Losses Cost ($)	$ 44,040,900.00

Moreover, we have initial cost per connection that is 125,000.00 dollars for each connection. We will connect 2 times so that makes **250,000.00 dollars** at total.

And lastly, we have the initial cost from the system without the wind turbine system, which was shown earlier at the beginning of the report that is 23,454,900.00 dollars we do not consider this money in the construction cost of the system which shown in experiment 9.

The cost to construct the system shown in Experiment 9 will be 55.090.900 dollars in 5 years scope.

At the end total system cost will be 78.545.800 dollars for total system all from beginning.

Conclusion

As conclusion, there is only 2 working case all from the 27 experiments. I found the best case as Experiment 9 which is connection FOPS to PETE with CONDOR conductors and connection FOPS to PAI with CONDOR conductors. That connection type costs less money and loses minimum amount power in the system

As a power engineer I recommend connection system with CONDOR conductors to stations PETE and PAI which costs 55.090.900 dollars to construct wind turbine system.

At the end total cost will 78.545.800 dollars for all city system in the scope of 5 years even if we construct the system in Experiment 9 and that is the best case in terms of money and system lose.

TO SEE EXPERIMENTS AND RESULTS CLICK ON IMAGE

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