

**GRID CONNECTED SOLUTION ABOUT
INTEGRATION OF YELKAPAN AND CENTER PIVOT IRRIGATION SYSTEM**

The General Concept

The main problem at the utilization of wind energy for irrigation is to make use of excess energy produced by wind turbine during winter months. Because no irrigation is performed during the winter.

Grid connected solution is the simplest solution. In this case, the grid can be used as a kind of energy storage system during the winter period. Net metering system is the key tool for the solution.

Yelkapan can produce electricity for the grid during winter months and use same amount of electricity from the grid to empower its own piston pump during irrigation season.

A reservoir is necessary to storage water during the period between consecutive run times of CPS.

No backup power supply system is necessary; because the system already connected to grid.

According to Parigi, Gachovska, Hudgins and Petterson "*The majority of irrigation pumping in Nebraska uses fossil fuels such as diesel, nature gas, and propane. An increasing percentage of irrigation pumping is however done by using electrical energy (42% at present).*" (see the article named "wind for irrigation application", University of Nebraska).

Basic Consideration for Capacity Calculations of Yelkapan

The annual energy production of Yelkapan should be equal to total energy demand of center pivot system during the irrigation season.

TOTAL BENEFIT OF YELKAPAN

If Yelkapan runs 12 months per year:
 A submersible pump does the same annual job with Yelkapan by using 65 630 kWh electricity.
 1 kWh electricity price in US is 0,07 USD
 Yelkapan saves 4 594 USD annual electricity bill.
 Yelkapan has 20 years effective operation life
 Yelkapan saves **91 880 USD** electricity bill during its lifetime.

TARGET PRICE

Our target price is maximum
 2 750 USD per kW for **30 kW** grid-connected Yelkapan (Total **82 500 USD**)

SAVING COSTS

The costs below will be saved by replacing existing solution with grid-connected Yelkapan solution.

20 years operating cost	91 880 \$
60 HP submercible pump cost	12 000 \$
<u>75 HP diesel or electric motor to run the system</u>	<u>20 000 \$</u>
Total Saving Costs	123 880 \$

REQUIRED YELKAPAN QUANTITY FOR EACH CPS

30 kW D64/30 Yelkapan with Average Daily Capacity Factor of 33000 :

Water depth	Average Daily Flow Rate [m ³]	Annual Flow Rate [m ³]
100 ft	1100	400 000
200 ft	550	200 000
300 ft	366	133 800

20% of annual energy production of a single Yelkapan is equal to energy demand of a single CPS itself and pump water from reservoir.

Water demand of a CPS is approximately 160 000 m³ per year if the flow rate is 1000 GPM, pump runs 17 hours per cycle and 42 times irrigation performed per year.

100 ft	2 Yelkapan for 3 CPS	0,66	unit per CPS
200 ft	1 Yelkapan for 1 CPS	1	unit per CPS
300 ft	3 Yelkapan for 2 CPS	1,5	unit per CPS

Grid connected solution saves 50% investment cost of Yelkapan according to stand-alone solution.

45 kW size new Yelkapan design is required for 300 ft well depth.

Basic Properties of Typical Center Pivot System (CPS)

Informations below were taken from the document of “Texas Agricultural Extension Services”.

Radius of the disc :	1500 foot
Irrigation area :	147 acre
Flow rate	1000 GPM
End tower travel speed	362 ft/h (26 hours per cycle) 546 ft/h (17 hours per cycle)
Water demand per cycle	5 896 m ³ for 26 hours 3 855 m ³ for 17 hours
Number of towers	10
Pressure loss	10 psi (6,7 meter Water column)
Irrigation Scheduling	Twice weekly



Average daily flow rate 1 684 m³ per day (26 hours per cycle)
1 101 m³ per day (17 hours per cycle)
(see below for average daily flow rate definition)

Power Demand of CPS

Drive system	1 – 1,5 HP per tower Assumed 10 kW for total
Water pump	7,5 kW for pressure loss

Total power demand of a center pivot system is **17,5 kW**

Attention on Hub Construction of Center Pivot System

It is not possible to locate Yelkapan at hub of the system. Yelkapan and water-well must be outside of the circle. There should be underground piping between Yelkapan and hub point of pivot system.