CSP STUDIES AT YETAM-HACETTEPE UNIVERSITY

Aynur ERAY
Hacettepe University

Hacettepe University- YETAM

New and Clean Energy Research and Application Center 1993

- educational and informational studies,
- academic research
- application studies about renewable energy


YETAM
GÜNEŞ EVİ
2001


BAŞLANGIÇ
BİSİKLET YOLU
BİTİŞ
BİSİKLET YOLU

Sun Dials Park 2008

Beytepe Campus

Hacettepe University
Renewable Energy Graduate Program
2005

Physics Engineering	Prof. Dr. Demir INAN
	Prof. Dr. Aynur ERAY
	Prof. Dr. Yılmaz KAPTAN
	Prof. DR. Necdet BAŞTÜRK
	Assoc. Prof. Mehmet DİLAVER
	Assis Prof. Akın BACIOĞLU
Environmental Engineering	Prof. Dr. Ayşenur UĞURLU
	Assoc. Prof. Dr. Selim SANIN
	Assis. Prof. Merih Aydınalp KÖKSAL
Mechanical Engineering	Assos. Prof. Murat KÖKSAL
	Assis. Prof. Özgür EKİCİ

Chemical Engineering	Prof. Dr. Tülay DURUSOY
	Prof. Dr. Deniz TANYOLAÇ
Electronic Enginnering	Prof. Dr. Işık ÇADIRCI
Geological Engineering	Prof. Dr. Şakir ŞİMŞEK
	Prof. Dr. Mehmet EKMEKÇİ
Nuclear Energy Engineering	Assos. Prof. Ayhan YILMAZER
	Assos. Prof. Şule ERGÜN
Chemistry	Prof. Dr. Fatma Sevin DÜZ
Faculty of Economy	Prof. Dr. Burak GÜNALP
	Prof. Dr. Necmiddin BAĞDADİOĞLU

Analyzing of Dish type Concentrated Solar Power Systems, using Stirling Cyle and Modeling Prototype

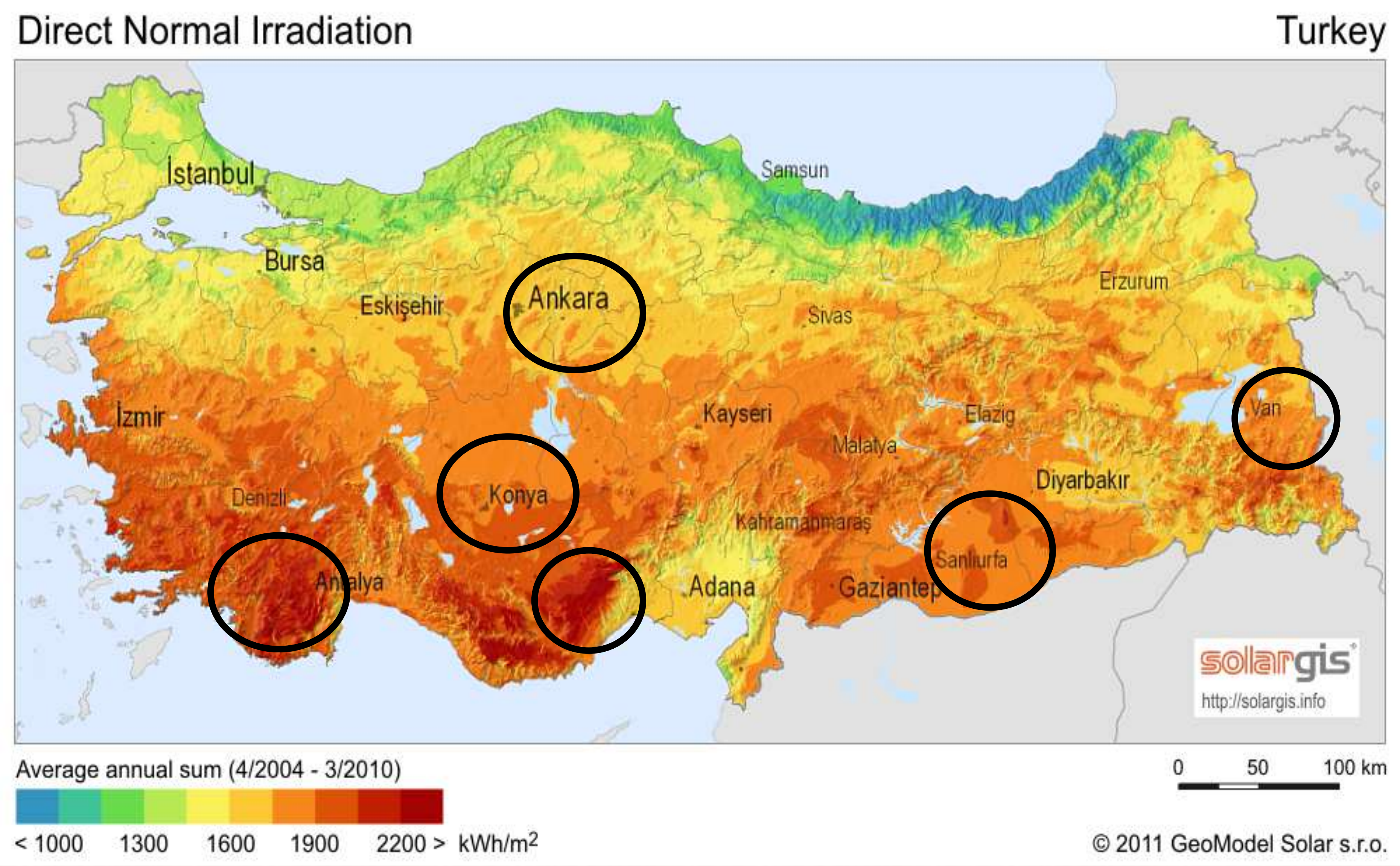
GÜLİN ACAROL ZİLANLI 2013

Application of Birecik Solar Power Plant with Central Receiver Sytem (CRS)

MEHMET HEKİM 2017

Motivation

- **To discuss the application of CSP systems in detail**
- **To pave the way for future studies in this field.**


Direct Normal Irradiation
Turkey
İstanbul
Samsun
Bursa
Eskişehir
Ankara
Sivas
Erzurum
İzmir
Kayseri
Malatya
Elazig
Van
Denizli
Konya
Diyarbakır
Kahramanmaraş
Sanliurfa
Antalya
Adana
Gaziantep
solargis
http://solargis.info
Average annual sum (4/2004 - 3/2010)
< 1000 1300 1600 1900 2200 > kWh/m2
0 50 100 km
© 2011 GeoModel Solar s.r.o.

Feasibility Study of Dish/Stirling Power Systems In Turkey

SES- Stirling Engine System

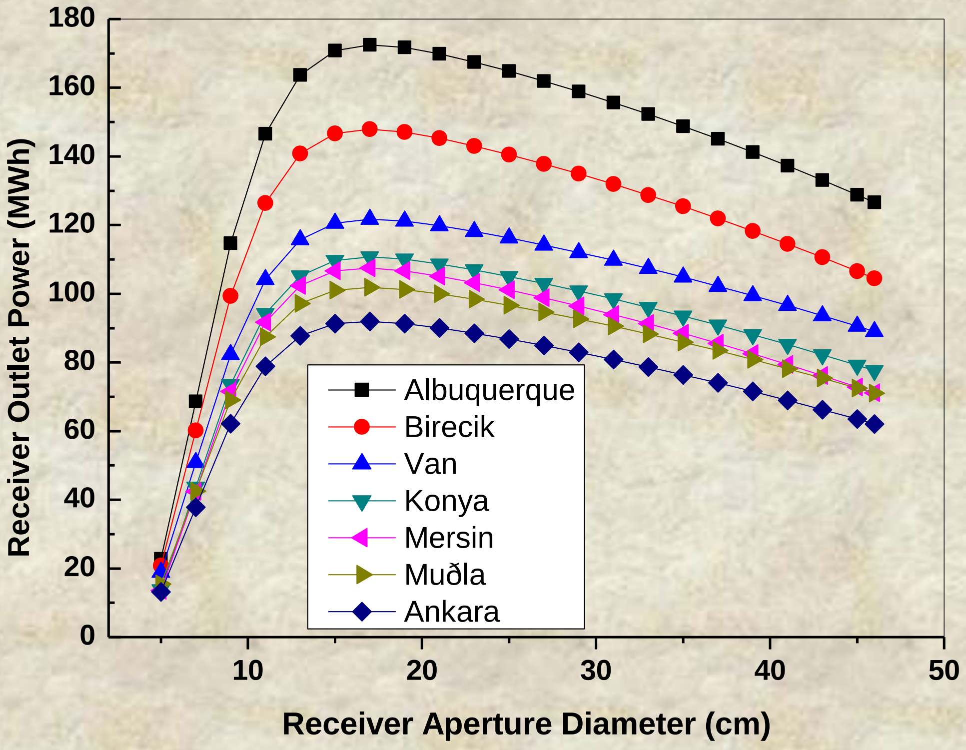
WGA- WGAssociates' Advanced Dish Development System

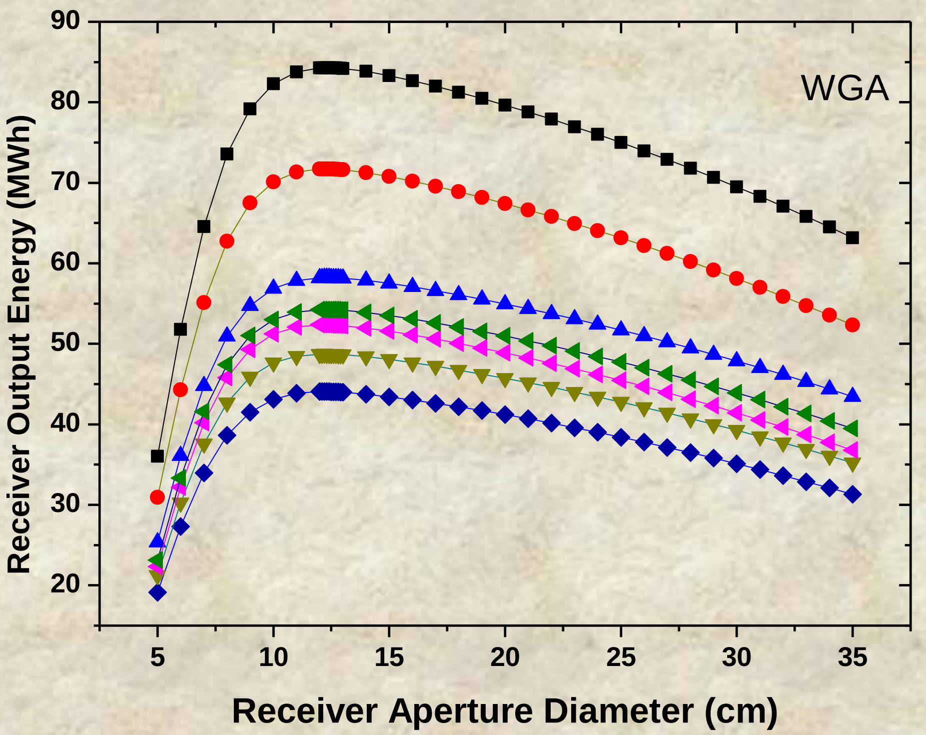
1. Optimization of System Parameters
2. Layout Design of SES/WGA Dish-Stirling Systems
3. Obtaining the system outputs

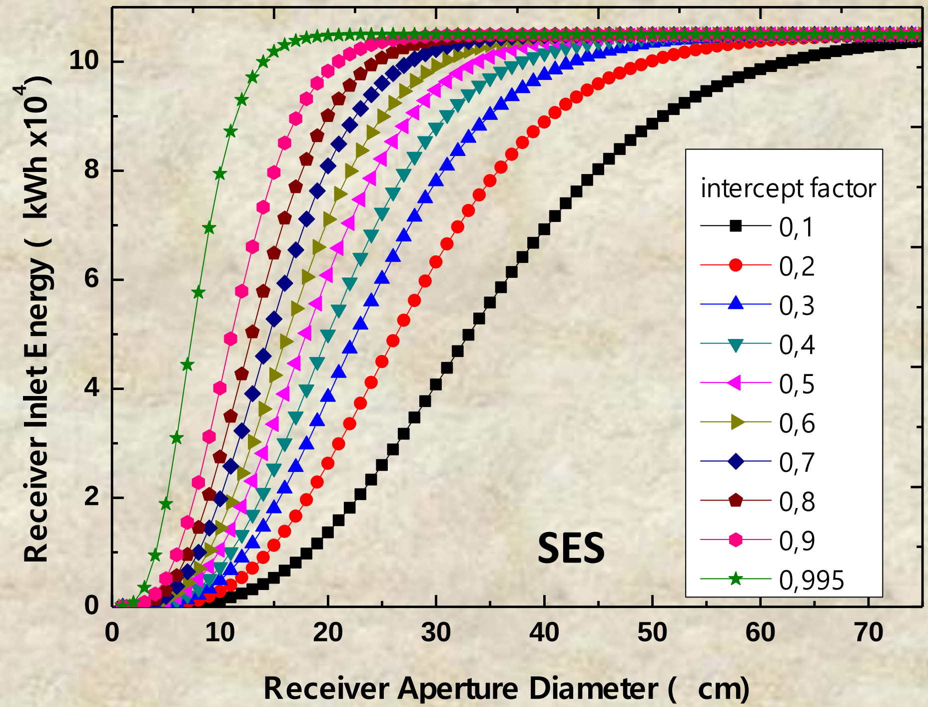
SIMULATION OF DISH/STIRLING SYSTEMS
Optimization of SES and WGA Dish/Stirling System Parameters

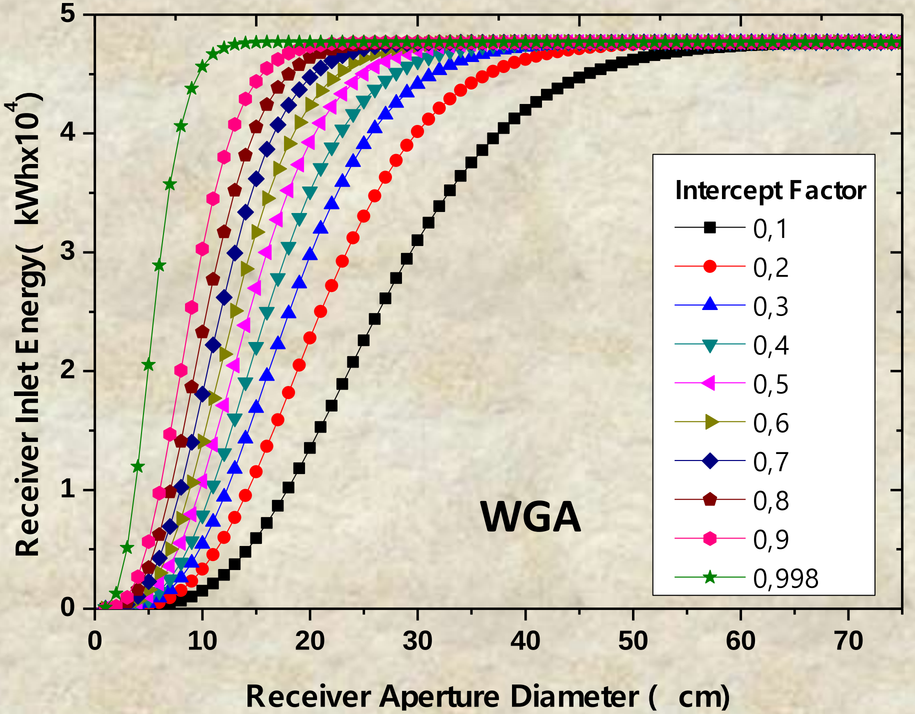
- Receiver aperture diameter,
- Intercept factor,
- Stirling engine absorber temperature,
- Concentration ratio
- Shading,
- Rim angle

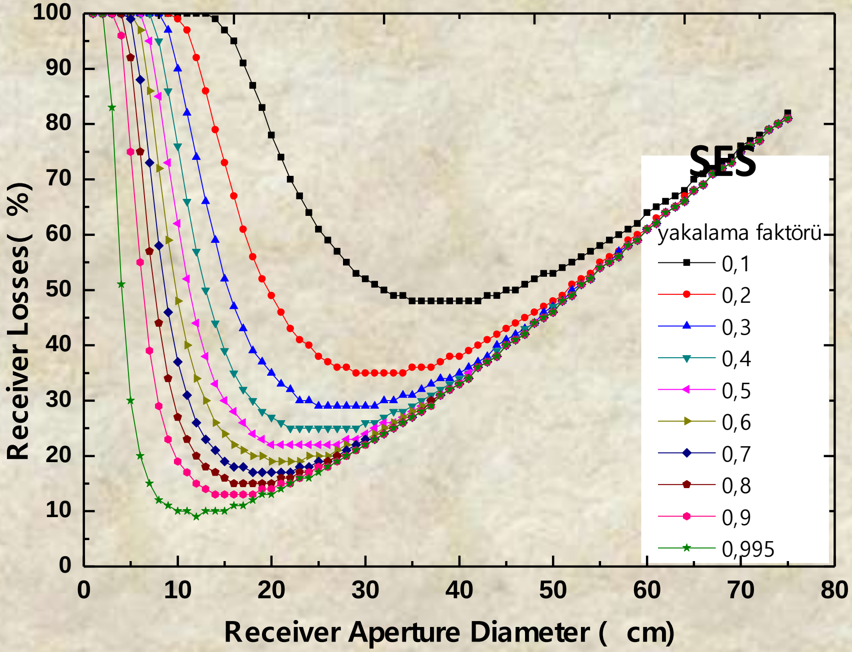
SIMULATION OF DISH/STIRLING SYSTEMS
Optimization of SES / WGA Dish/Stirling System Parameters

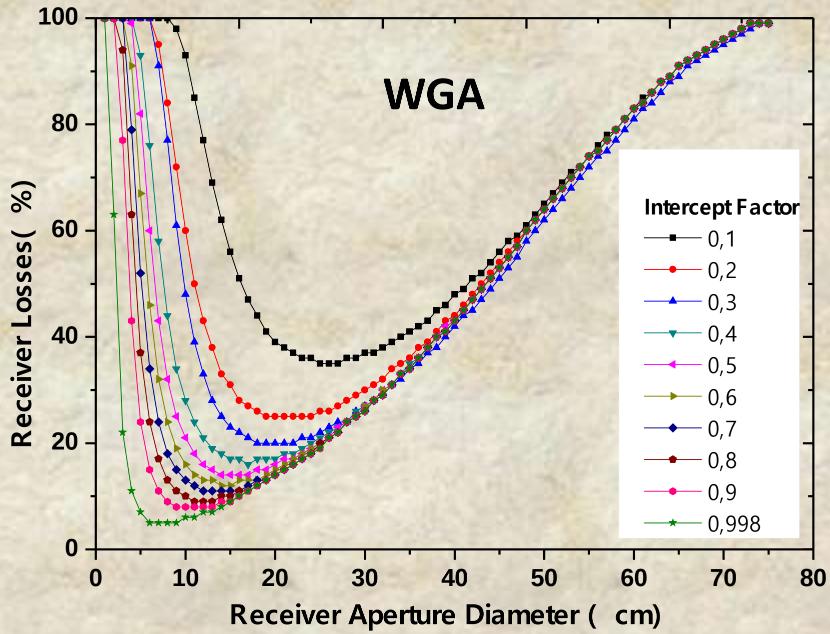





Receiver Inlet Energy (kWh x10^4)
Receiver Aperture Diameter (cm)
intercept factor
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
0,995
SES


Receiver Inlet Energy(kWhx10^4)
Receiver Aperture Diameter (cm)
Intercept Factor
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
0,998
WGA


SES
Receiver Losses(%)
Receiver Aperture Diameter (cm)
yakalama faktörü
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
0,995


WGA
Receiver Losses(%)
Receiver Aperture Diameter (cm)
Intercept Factor
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
0,998

SIMULATION OF DISH/STIRLING SYSTEMS

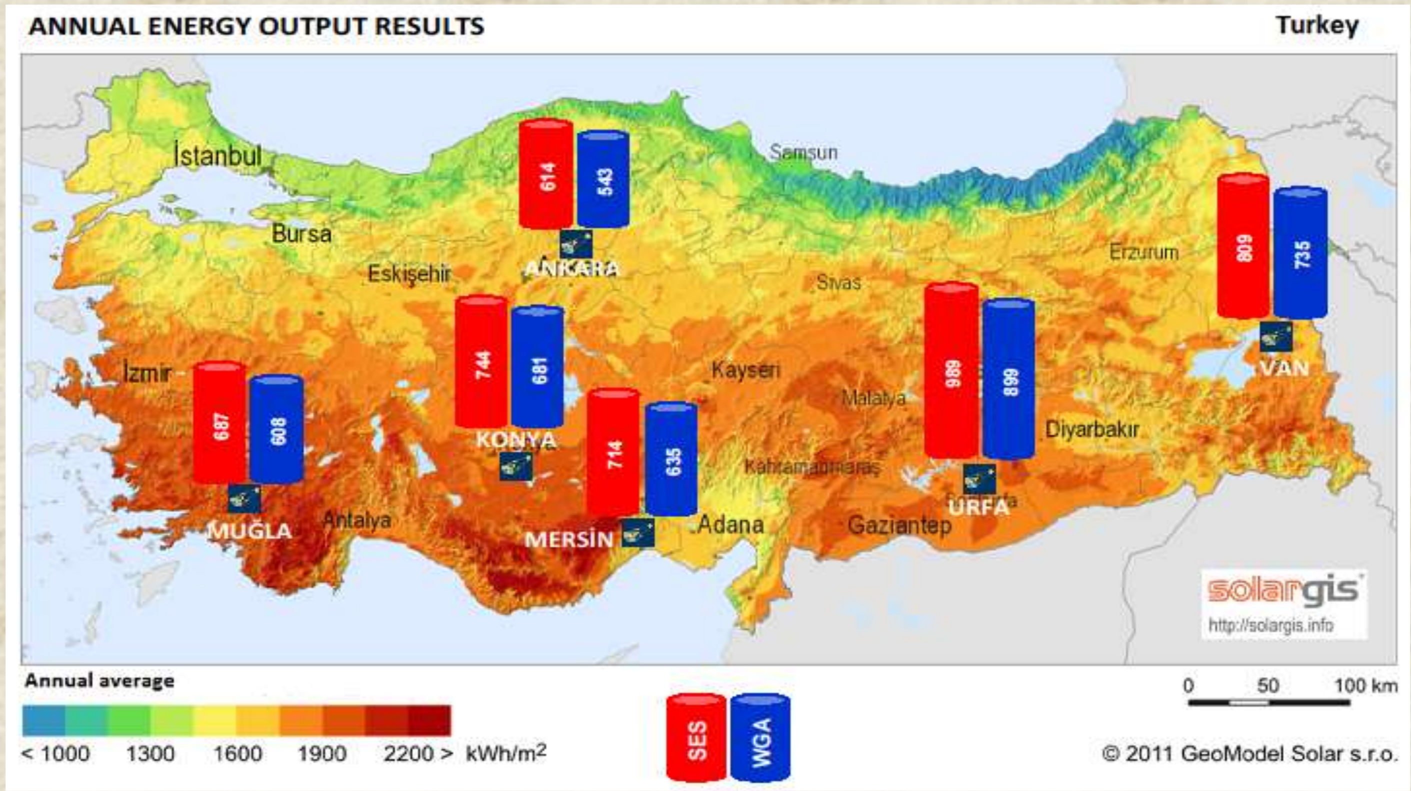
Annual Energy and capacity factor results for different layout of the 600 kW system

WGA (10kW)

Number of systems			Provinces						
N-S	E-W		Albuquerque	Urfa	Van	Konya	Mersin	Muğla	Ankara
1	60	AE (kWh)	882033	735427	607676	552683	504617	519045	443100
		CF (%)	16.8	14.0	11.6	10.5	9.6	9.9	8.4
12	5	AE (kWh)	1094329	887988	730090	672873	619763	598687	534055
		CF (%)	20.8	16.9	13.9	12.8	11.8	11.4	10.2
20	3	AE (kWh)	1101470	893435	734310	677332	624365	601757	537678
		CF (%)	21.0	17.0	14.0	12.9	11.9	11.4	10.2
60	1	AE (kWh)	1111018	899853	738661	683387	630495	605938	542566
		CF (%)	21.1	17.1	14.1	13.0	12.0	11.5	10.3

SES (25kW)

Number of systems			Provinces						
N-S	E-W		Albuquerque	Urfa	Van	Konya	Mersin	Muğla	Ankara
1	24	AE (kWh)	969533	834903	678019	618431	589165	596542	517614
		CF (%)	18.4	15.9	12.9	11.8	11.2	11.3	9.8
4	6	AE (kWh)	1137747	955291	784282	718757	684591	666044	592467
		CF (%)	21.6	18.2	14.9	13.7	13.0	12.7	11.3
8	3	AE (kWh)	1168839	977846	803497	737552	702376	679081	607758
		CF (%)	22.2	18.6	15.3	14.0	13.4	12.9	11.6
24	1	AE (kWh)	1201915	1002093	822460	757439	721022	693670	628704
		CF (%)	22.9	19.1	15.6	14.4	13.7	13.2	12.0



Province		Albuquerque	Urfa	Van	Konya	Mersin	Muğla	Ankara
Annual Energy (MWh)	SES	1179	989	809	744	714	687	614
	WGA	1103	899	735	681	635	608	543

Average Efficiecy (%) for 600kW SES system

Albuquerque

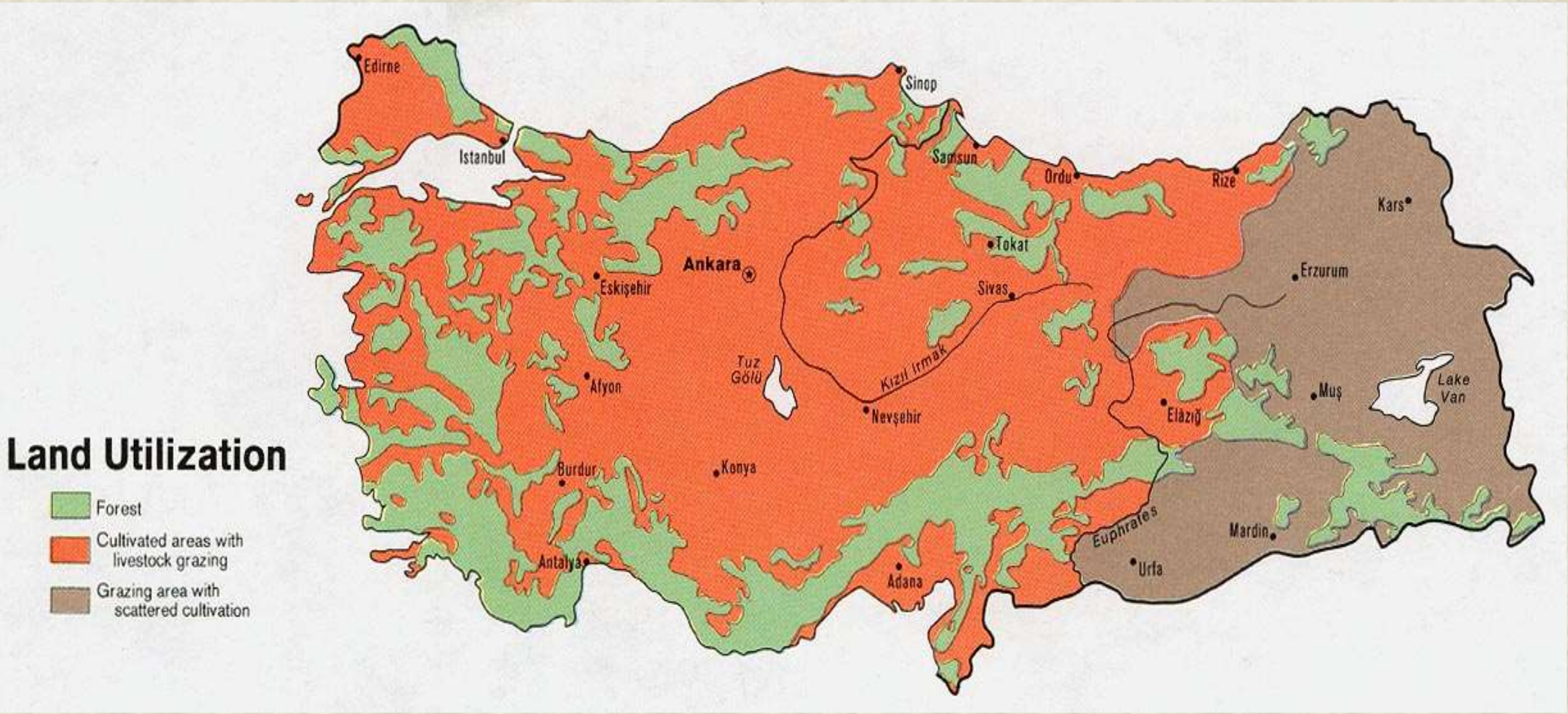
a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
5 AM	0	0	0	0	0	0	0	0	0	0	0	0
6 AM	0	0	0	0	0	0	0	0	0	0	0	0
7 AM	0	0	3	13	21	22	17	13	7	5	0	0
8 AM	5	7	13	20	25	24	24	21	18	18	13	7
9 AM	15	14	19	22	25	25	25	24	20	21	20	19
10 AM	19	21	18	23	25	25	25	25	20	21	20	21
11 AM	19	21	17	24	24	25	26	25	22	21	22	21
12 PM	18	22	17	22	23	24	25	25	22	22	21	20
13 PM	19	23	20	21	24	24	25	25	23	23	21	20
14 PM	19	22	18	20	23	20	23	22	22	23	22	18
15 PM	18	21	16	18	17	18	22	20	21	21	21	20
16 PM	18	20	13	16	18	18	14	20	19	20	18	17
17 PM	11	17	14	14	15	14	11	15	14	13	7	8
18 PM	0	1	5	9	13	12	8	8	5	1	0	0
19 PM	0	0	0	1	3	6	2	1	0	0	0	0
20 PM	0	0	0	0	0	0	0	0	0	0	0	0

Urfa

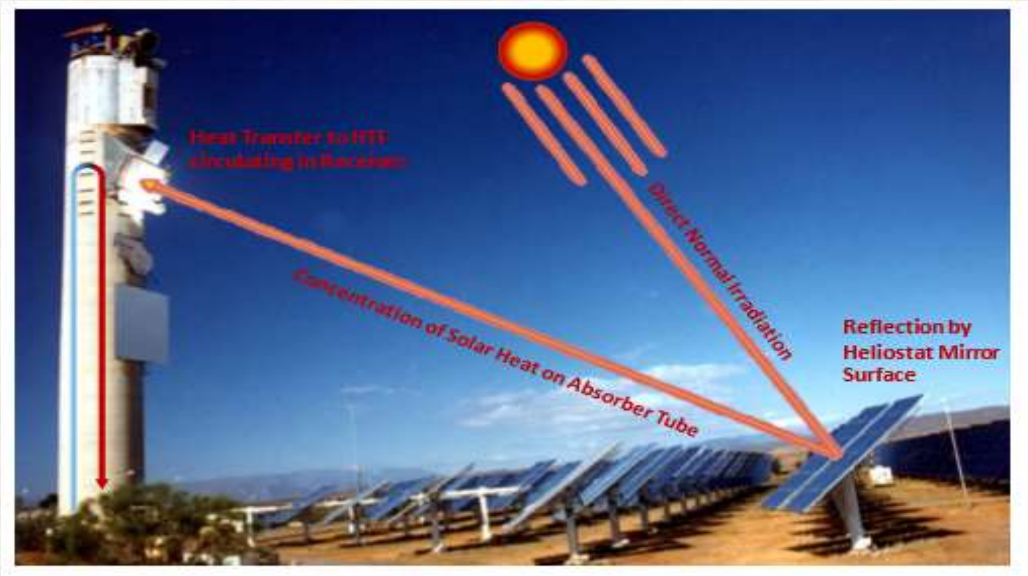
b)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
5 AM	0	0	0	0	0	0	0	0	0	0	0	0
6 AM	0	0	0	4	15	17	15	15	1	0	0	0
7 AM	0	0	11	16	22	22	24	24	18	11	4	0
8 AM	10	9	16	17	23	24	25	25	22	17	17	11
9 AM	15	13	17	18	21	24	25	26	24	19	18	15
10 AM	14	14	17	20	22	24	25	26	24	20	17	16
11 AM	15	14	16	18	23	24	25	26	23	23	19	15
12 PM	13	14	17	16	19	23	22	25	24	23	19	15
13 PM	14	16	18	17	19	22	21	25	24	22	18	16
14 PM	16	18	17	17	18	21	21	25	23	19	20	19
15 PM	17	17	18	17	17	21	21	24	22	18	20	20
16 PM	12	16	16	13	18	21	21	24	22	14	12	12
17 PM	0	5	10	10	17	20	20	21	11	1	0	0
18 PM	0	0	0	2	11	12	10	9	0	0	0	0
19 PM	0	0	0	0	0	0	0	0	0	0	0	0
20 PM	0	0	0	0	0	0	0	0	0	0	0	0

%	0 - 5	6 - 10	11 - 15	16 - 20	21 - 24	≥ 25

Land Utilization



the technical analysis of a CRS (Solar Thermal Tower) plant with a capacity of 10 MW in Birecik



Annual Electricity Generation

Optimization of critical components of heliostat field and receiver for obtaining the maximum annual electricity for the year 2005

The optimum component values of heliostat field and receiver to maximise the annual energy production from 10 MW Birecik CRS plant

- Width and height of each heliostat are 8 m. and 20 m. respectively
- The ratio of the reflector area to profile area is 0,97
- Diameter of receiver is 8,5 m.
- Number of panel pairs in the receiver is 18
- Absorbtance and emittance of receiver coating are 0,98 and 0,1 respectively
- Height of boiler is 3,5 m.
- Outer diameter of boiler tubes is 0,02 m
- Thickness of boiler tubes is 0,0012 m.
- Material of boiler tubes is T91 steel
- Height of superheater is 2,8 m.
- Outer diameter of superheater tubes is 0,02 m.
- Thickness of superheater tubes is 0,0012 m.
- Material of superheater tubes is T91 steel
- Height of reheater is 1,3 m.
- Outer diameter of reheater tubes is 0,02 m.
- Thickness of reheater tubes is 0,0012 m.
- Material of reheater tubes is T91 steel
- Flow pattern 2, from south to north
- Evaporative cooling

- **Electricty Production**

  25.417 MWh/year

- **capacity factor**

  29 %

	Location	Capacity MW	Irradiation $kWh/m^2/year$	Latitude Longtitude	Storage (hour)	Electricty Production MWh/year
Crescent Dunes	Tonopah, Nevada US	110	2.685	38°14′ 20.0″ North 117°21′ 48.0″ West	10	500.000
Golmud	Goldmud China	200	2.158	36°24′ 22″ North 94°54′ 37″ East	15	1.120.000
Planta Solar 10 (PS10)	Sevilla Spain	11	2012	37°26′ 30.97″ North 6°14′ 59.98″ West	1	23.400
Planta Solar 20 (PS20)	Sevilla Spain	20	2012	37°26′ 30.97″ North 6°14′ 59.98″ West	1	48.000
Birecik CRS	Birecik Türkiye	10	1994	37,5 °North 37,9° East	0	25.417

CONCLUSION

- CSP technologies seems to be an interesting opportunities for Turkey.
- Turkey's energy policy target for renewable energy share

  20% by the year of 2020,

  30% by the year of 2050

there is no advanced application of CSP up to now.

- To improve these technologies in Turkey, it seems to be necessary to get the governmental supports and new strategies.

NEXT STEPS

- Numerical and experimental investigations of soiling and dust effect on CSP performance
- Life cycle assessment of CSP plants
- Planning of a 100% renewable energy system based on the integration of a CSP plant and desalination units
- Performance analysis and techno-economic analysis of a CSP plant hybridized with both thermal energy storage and natural gas


Thanks for your attention