



The HOMER Simulation Tool PROS & CONS

ECREEE Regional Training of Trainers Workshop:
HOMER software for RE project design

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I. IDEAL EXAMPLE

Considerations:

Dimensioning and Simulating



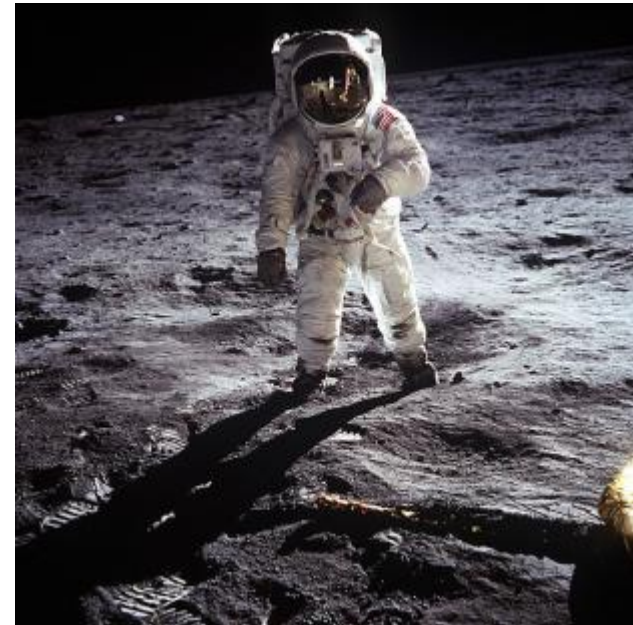
What is dimensioning and simulating in this training?

IDEAL EXAMPLE

“Consider that our purpose is to build a spacecraft to reach the moon.”

Before building it, you have **to understand the physics behind and the available technology** before you start such a complex project.

- The equations are related to **the model**, that will explain the behavior of your spacecraft in the context.
- The available technology **refer to the inputs** you will use (among other parameters such as restrictions).





Oversized results



M = instantaneous mass of rocket
 v = velocity of rocket
 t = time
 F = net force = thrust = $\dot{m} V_{eq}$
 V_{eq} = equivalent engine exhaust velocity = $isp \cdot g_0$

m_f = fuel mass
 m_e = empty mass
 m_p = payload mass
 isp = specific impulse

Newton's second law of motion: $\frac{d(Mv)}{dt} = F = \dot{m} V_{eq}$

If you have the technology and the real inputs, but you don't understand the model, it is very likely that your solution will be either oversized or wrong.

$$\Delta v = V_{eq} \ln\left(\frac{m_f}{m_e}\right) = V_{eq} \ln(MFR) = isp \cdot g_0$$





Unrealistic results

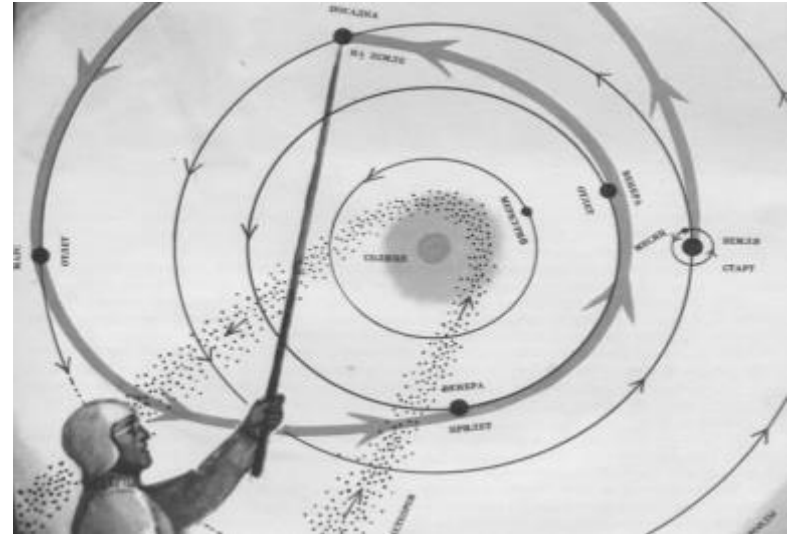
If you understand the model, but you don't have the proper technology data and real inputs, it is very likely that your solutions will be either unrealistic or wrong.





Criteria and convergence

- It is the human, with criteria who drives the simulation software to converge to feasible solutions.
- If you start a simulation without criteria, probably you will face a situation of many (or none) results without finding a good solution.





Simulating different sizes and all the possible combinations

IN THIS IDEAL EXAMPLE OF A SPACECRAFT,

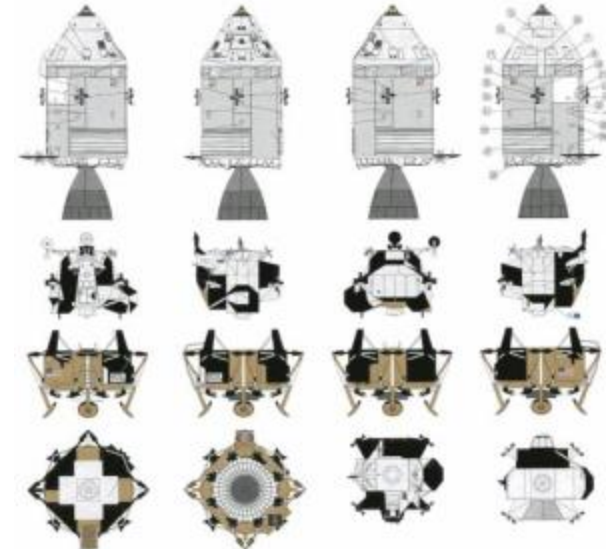
Through a **computer simulation** we can try different sizes (or dimension) of the components for a spacecraft, as well to set different technology combinations and restrictions ...

[the computer **runs** the model **with our inputs**]

... and then we can analyze the results: **a list of feasible technology combinations.**

Finally, we select the more convenient solution for our purpose taking into account several parameters and conditions.

15886	23892	24432	10248	21866	7154	28609
10303	5267	31647	9110	12492	25736	14119
8418	27173	5336	252	14541	6608	9682
23401	18953	26527	6767	18296	11165	19042
27833	29497	9104	1969	31178	3644	32289
13509	26832	24828	24252	2339	23463	30942
14085	14763	1017	24574	17948	25744	6483
25752	15301	26260	24918	6896	24114	15146
14377	27330	27370	30020	32178	22052	32524
22257	2668	837	1043	4107	4007	31288
885	26623	8598	25313	10685	30238	10893
24002	9754	10473	30931	31881	30394	6427
610	17764	15007	17624	14939	26492	6284
25659	9350	24213	9928	30079	13335	22020
3055	27142	24699	15551	10235	26976	21075

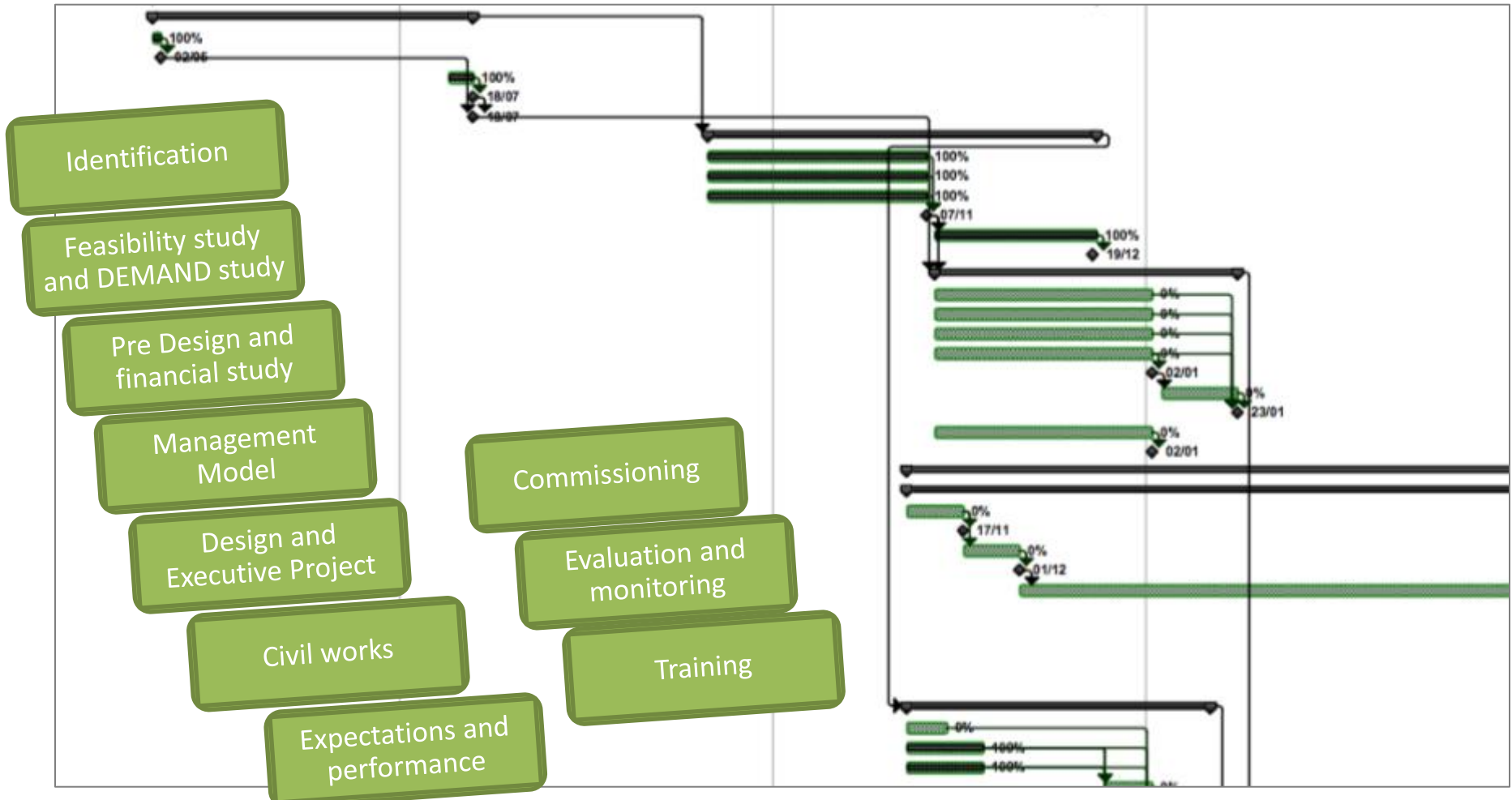


II. HYBRID ENERGY SYSTEM SIMULATION

What HOMER software does.



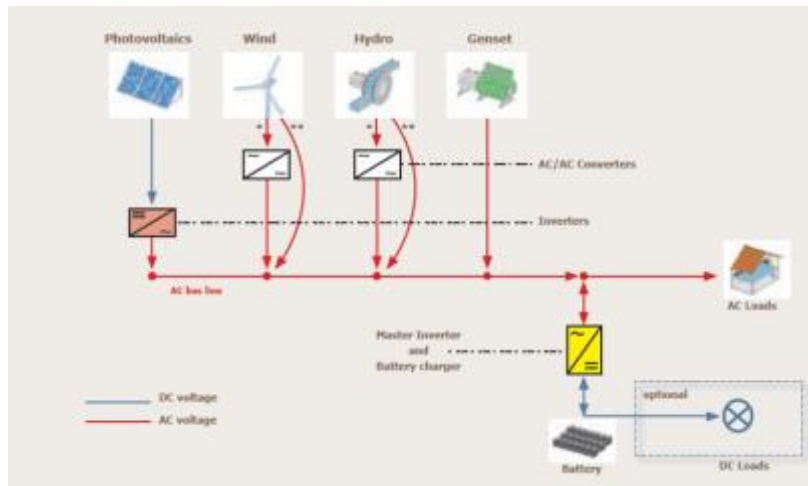
Life cycle project: stages, dimensioning, simulation and design





MAIN PURPOSE OF THE SIMULATION: “to dimension conveniently”

- **TO DIMENSION** an hybrid energy system
 - **Generator size**
 - for a given energy demand
 - for a given list of available technology and restrictions to consider





HOMER SIMULATES DIFFERENT SIZES (dimensioning) OF THE SYSTEM

- A dimensioning tool (also referred to as a sizing tool) performs dimensioning of the system: given an energy requirement, it determines the *optimal size of each of the different components of the system*
- With simulation tools, as opposed to dimensioning tools, the user must specify the nature and size of each component. *The tool then provides a detailed analysis of the behavior of the system.*

- **Simulation tools can also be used for sizing.** This requires that the user correctly identify the key variables and then repeatedly run the simulation, adjusting the variables manually **to converge** on an acceptable sizing. Some packages automate this process.



Simulation in HOMER

- To use HOMER, you provide the model with **inputs**, which describe technology options, component costs, and resource availability.
- HOMER uses these inputs to **simulate different system configurations, or combinations of components**, and generates results that you can view as a list of feasible configurations sorted by net present cost.
- HOMER also **displays simulation results in a wide variety of tables and graphs** that help you **compare configurations and evaluate** them on their economic and technical merits.



List of feasible solutions

File View Inputs Outputs Window Help

Equipment to consider: Add/Remove...

Calculate Simulations: 0 of 48 Progress: Sensitivities: 0 of 4 Status:

Sensitivity Results Optimization Results

Sensitivity variables

Primary Load 1 (kWh/d) 160 PV Slope (deg) 24

Double click on a system below for simulation results.

	PV (kW)	E70	Gen (kW)	H1500	Conv. (kW)	Initial Capital	Operating Cost (\$/yr)	Total NPC	CDE (\$/kWh)	Ren. Frac.	Capacity Shortage	Diesel (L)	Gen (hrs)
	21	3	36	48	15	\$ 162,437	20,322	\$ 395,528	0.603	0.83	0.02	4,991	619
	30	3	36	48	15	\$ 178,187	19,401	\$ 400,711	0.598	0.90	0.00	3,351	428
	22	3	36	48	15	\$ 164,187	20,717	\$ 401,808	0.607	0.83	0.01	4,995	631
	23	3	36	48	15	\$ 165,937	20,993	\$ 406,722	0.612	0.84	0.01	4,996	635
	40	3	36	48	15	\$ 195,687	18,421	\$ 406,974	0.608	0.95	0.00	1,817	236
	40	2	36	48	15	\$ 179,687	19,977	\$ 408,827	0.610	0.93	0.00	2,513	323
	24	3	36	48	15	\$ 167,687	21,258	\$ 411,514	0.616	0.84	0.00	4,992	636
	25	3	36	48	15	\$ 169,437	21,174	\$ 412,296	0.616	0.85	0.00	4,830	616
	30	2	36	48	15	\$ 162,187	22,337	\$ 418,386	0.625	0.85	0.00	4,778	626
	50	2	36	48	15	\$ 197,187	20,225	\$ 429,164	0.641	0.96	0.00	1,651	219
	50	3	36	48	15	\$ 213,187	18,988	\$ 430,976	0.643	0.98	0.00	1,141	155
	40	1	36	48	15	\$ 163,687	23,484	\$ 433,044	0.646	0.88	0.00	4,155	546
	50	1	36	48	15	\$ 181,187	22,363	\$ 437,690	0.653	0.94	0.00	2,576	336

Resources: AC Other

- Solar resource
- Wind resource
- Diesel
- Economics
- System control
- Grid extension
- Emissions
- Constraints

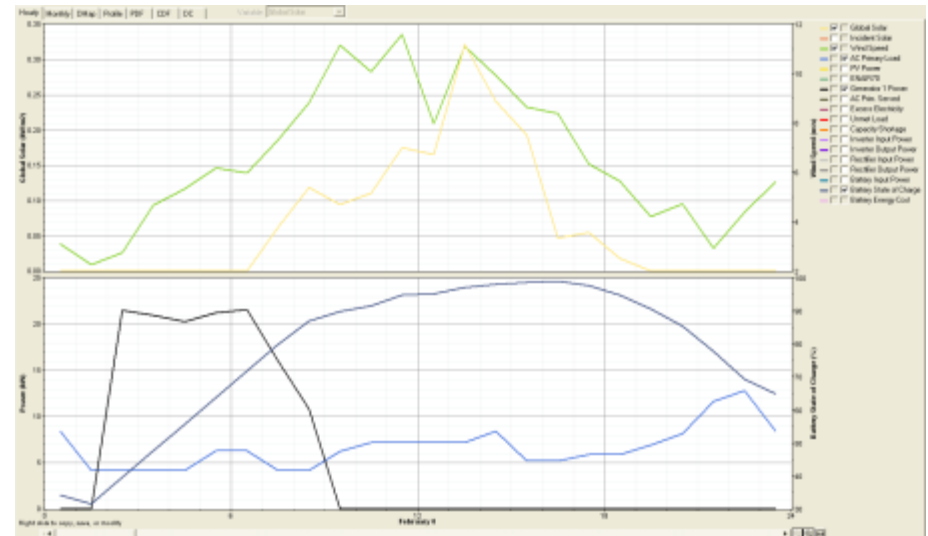
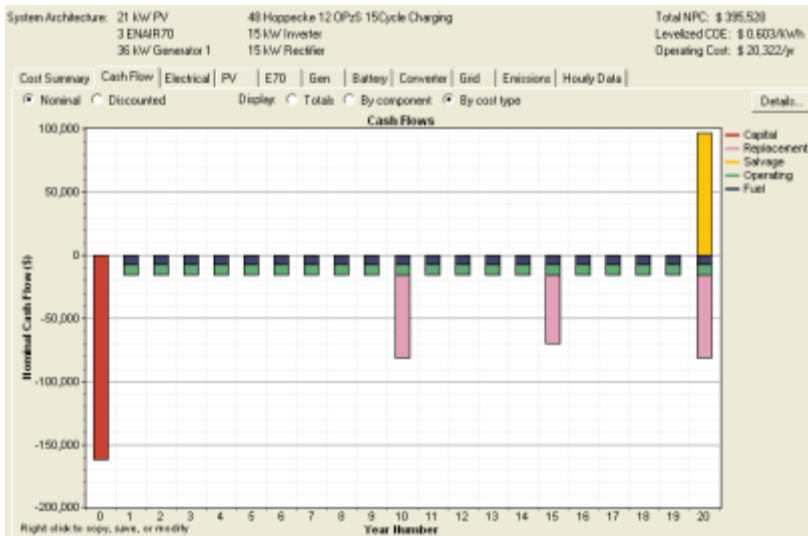
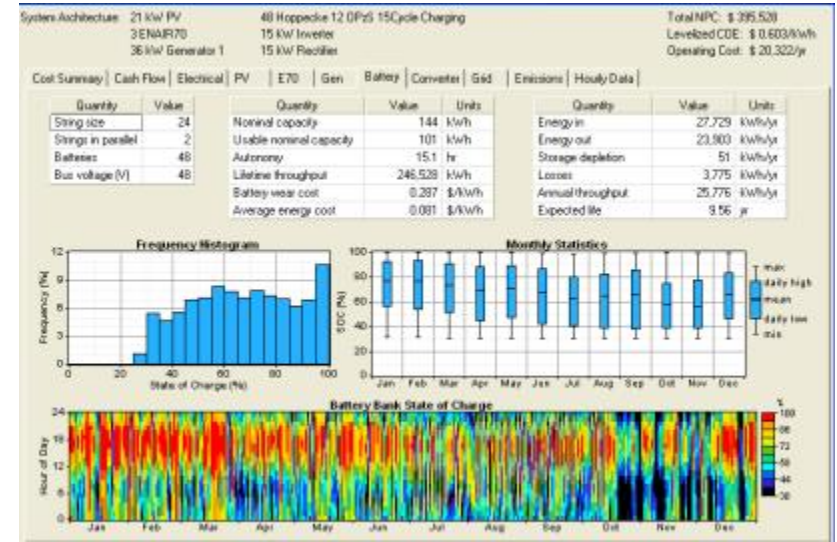
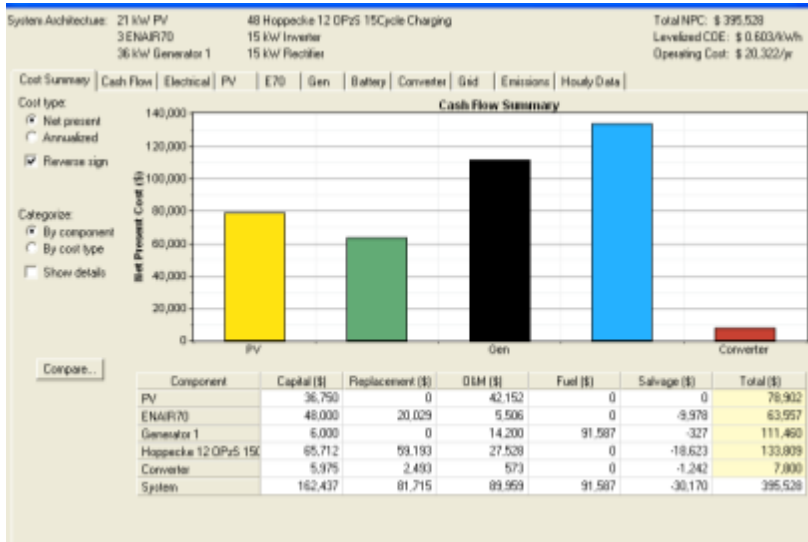
Document

Author: Sneij i Vilal

Notes



Evaluation of each solution: economics and technical performance



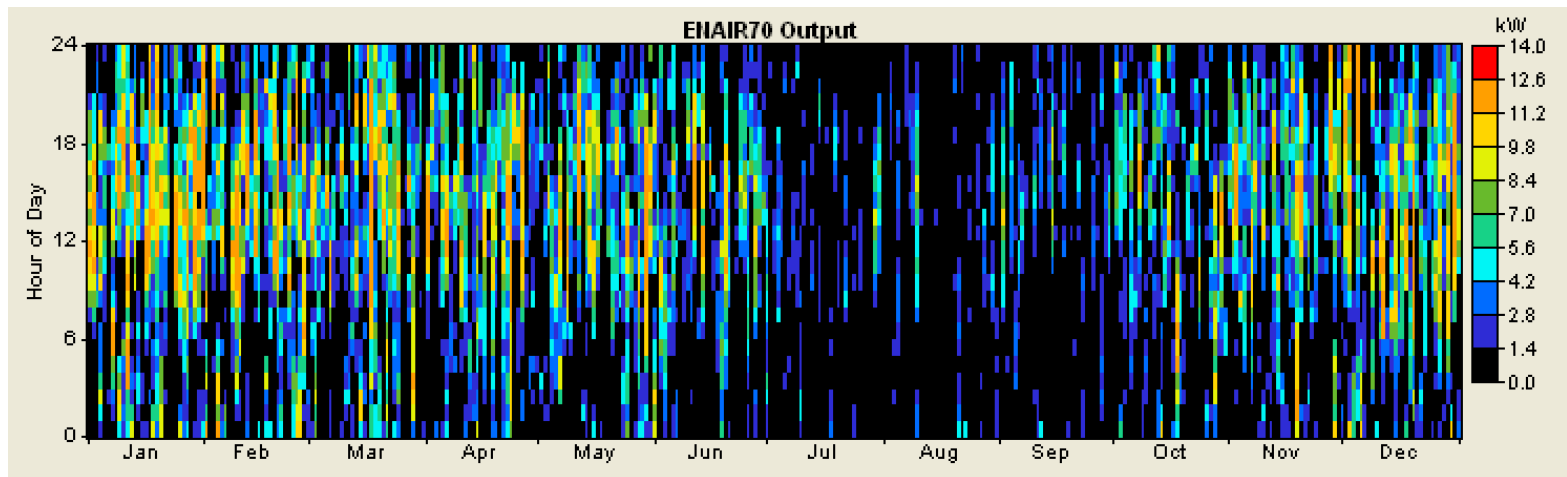
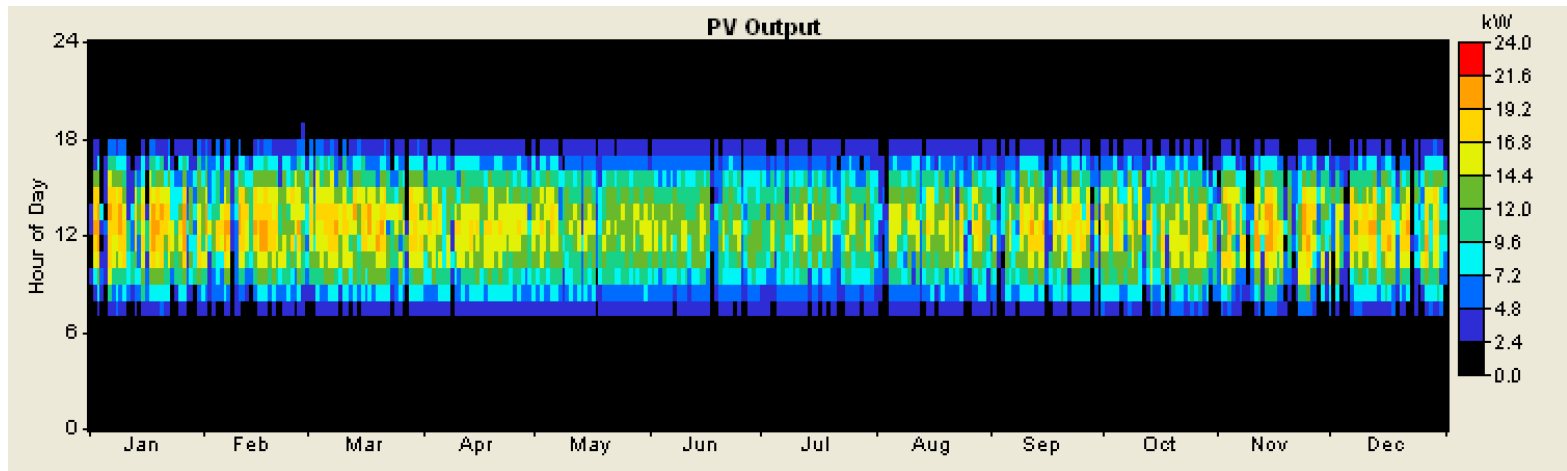


How does HOMER work ?

- HOMER simulates the operation of a system by making energy balance calculations for each of the 8,760 hours in a year.
- For each hour calculates the flows of energy to and from each component of the system.
- HOMER performs these energy balance calculations for each system configuration that you want to consider.
- It then determines whether a configuration is feasible, i.e., whether it can meet the electric demand under the conditions that you specify.
- It estimates the cost of installing and operating the system over the lifetime of the project.



Hourly energy balance calculations



III. PROS & CONS

Advantages and Disadvantages



HOMER

Among other aspects to debate, we may say that for this training HOMER has some advantages and disadvantages.

PROS	CONS
Simulates a list of real technologies, as a catalogue of available technologies and components.	Quality input data needed (sources).
Very detailed results for analysis and evaluation.	Detailed input data (and time) needed.
Determines the possible combinations of a list of different technologies and its size.	Experienced criteria is needed to converge to the good solutions.
It is fast to run many combinations.	If you miss key values or sizes, HOMER will not guess them!
You can learn from the results, and optimize.	You can loose yourself if you don't set the adequate questions.

IV. HOW CAN THIS SIMULATION TOOL BE USEFUL TO YOU?

Examples, outputs, results and analysis



Two scenarios after this training

- **Audit of projects**

- You will be able to create a HOMER file, input the data used in a project or in a proposal, and get a list of feasible solutions. You may use the results to establish a dialogue with the hybrid system designer, and require more answers or justifications.

- **Site appraisal**

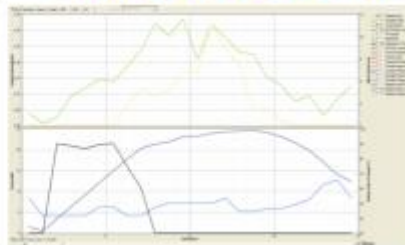
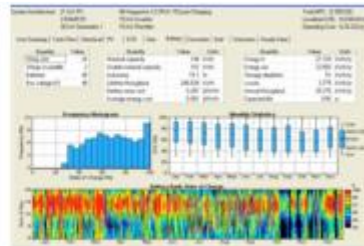
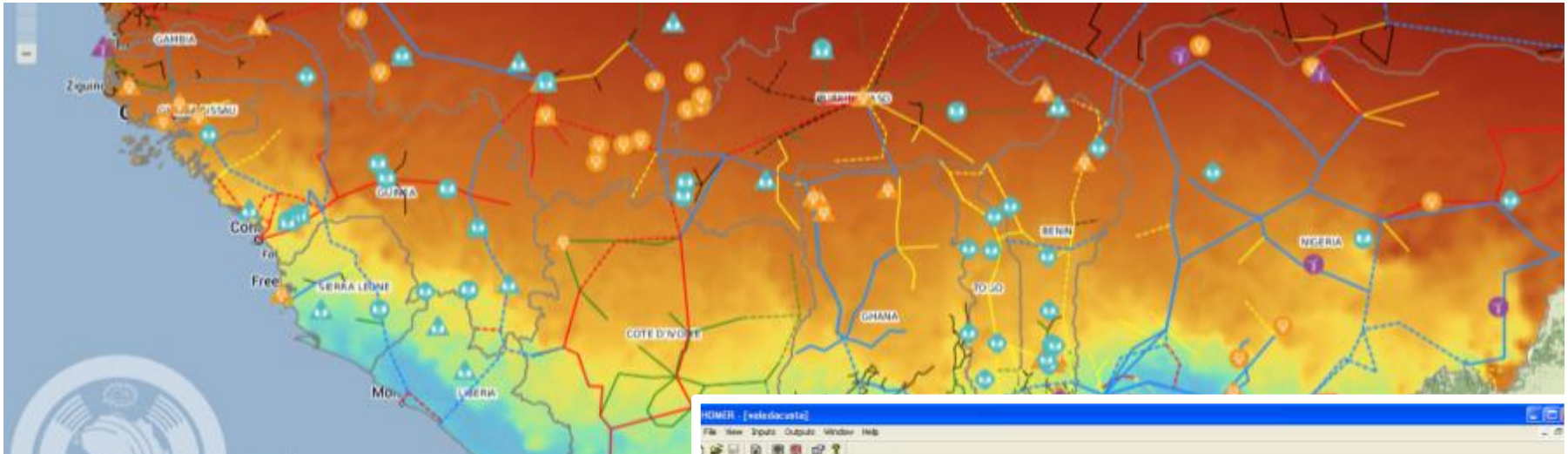
- You will be able to create a HOMER file, input relevant data and get a list of feasible solutions. You may use the results to develop insight into your designs (or plans), exploring the implications, reasoning key aspects and establish recommendations.

Audit scenario



Source: SOTEC, SMA and TTA

Appraisal scenario



HOMER [v2.10.0-beta2]

File New Inputs Outputs Window Help

upward to consider Add/Remove

Private Load 1
162 kWh/d
133 kWh/peak

ENR70

Generator 1

Converter

HT200

resources:

- Solar resource
- Wind resource
- Hydro resource
- Geothermal
- Coal
- Other

DC:

- Electricity
- System control
- Grid extension
- Emissions
- Constraints

current

other (Trees/Vital)

size

Calculate Simulations: 0 of 40 Progress: Status: 0 of 4

Sensitivity Results: Optimization Results

Sensitivity variables

Private Load 1 (kWh/d) 162 PV Slope (deg) 24

Double click on a system below for simulation results.

	PV (kW)	WT (kW)	Gen (kW)	HT100	Conv (kW)	Initial Capital	Operating Cost (\$/yr)	Total NPC	COE (\$/kWh)	Res. Fac.	Capacity Storage	Cost (\$)	Gen (kWh)
1	21	3	36	40	15	\$162,437	30,322	\$395,529	0.603	0.03	0.00	4,991	679
2	30	3	36	40	15	\$178,157	19,481	\$400,715	0.598	0.00	0.00	2,251	429
3	22	3	36	40	15	\$164,157	33,717	\$401,906	0.607	0.03	0.00	4,995	631
4	23	3	36	40	15	\$182,837	20,983	\$458,722	0.612	0.04	0.00	4,996	628
5	43	3	36	40	15	\$195,007	19,421	\$468,574	0.608	0.05	0.00	1,817	238
6	40	2	36	40	15	\$179,607	19,977	\$468,427	0.618	0.03	0.00	2,813	323
7	34	3	36	40	15	\$167,667	21,258	\$471,514	0.616	0.04	0.00	4,892	636
8	25	3	36	40	15	\$169,437	21,174	\$472,296	0.616	0.05	0.00	4,830	616
9	30	2	36	40	15	\$162,197	22,337	\$470,366	0.625	0.05	0.00	4,778	625
10	50	2	36	40	15	\$197,197	30,225	\$429,164	0.641	0.06	0.00	1,021	219
11	50	3	36	40	15	\$213,197	19,988	\$430,376	0.643	0.08	0.00	1,141	155
12	40	1	36	40	15	\$163,607	23,484	\$423,044	0.640	0.00	0.00	4,795	546
13	50	1	36	40	15	\$181,197	22,363	\$437,696	0.650	0.04	0.00	2,576	398

PV search space may be insufficient
 ENR70 search space may be insufficient
 Completed in 3 seconds.

Source: ECREEE and HOMER ENERGY



References

- *HOMER Energy (2011), Getting Started Guide for HOMER Legacy (Version 2.68), Homer Energy and National Renewable Energy Laboratory, Colorado.*
<http://www.ecowrex.org/document/getting-started-guide-homer-legacy-version-268>
- *IEA, (2011), Report IEA-PVPS T11- 01:2011 World-wide overview of design and simulation tools for hybrid PV systems.*
<http://www.ecowrex.org/document/world-wide-overview-design-and-simulation-tools-hybrid-pv-systems>



*ECOWAS Regional Centre for
Renewable Energy and Energy Efficiency*

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et l'Efficacité Energétique de la CEDEAO*

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Eficiência Energética da CEDEAO*

Merci! Thank you! Muito obrigado!

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