SOLAR PAYBACK - TRAIN-THE-TRAINER
SOLAR HEAT FOR INDUSTRIAL PROCESSES

Economic Assessment of SHIP

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SPB Train-the-Trainer Workshop

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Cash Flow Model
Inflows / Outflows

Regular approach for long-lasting, high productive real assets

<u>Revenues:</u>

Saved energy cost

Subsidies

Inflows →

Outflows →

<u>Expenses</u>:

Capital Expenses (CAPEX)

Operational Expenses (OPEX)

Financial Costs

Cash Flow Model for SHIP
Inflow

Inflow = Revenue from saved energy

- Annual energy yield
  - Forecast derived from simulations
  - Forecast vs. Realized revenues
  - Financial risk
  - Demands risk premium reflected in cost of capital (CoC)
- Conventional energy cost
  - Very volatile
  - Affected by energy price inflation

Cash Flow Model for SHIP
Outflow

- Investment
- Operational Expenditures
- Capital costs

Cash Flow Model for SHIP
Outflow - Investment Costs

- planning, material, components, installation
- Broad variation
  - Heat Transfer Medium — $ Air < Water < Steam < Thermal oil $
  - Process temperature — $ Up to 40°C < more than 120° $
  - Collector technology
  - System's complexity
  - Effort of connection & integration
  - Demand profile
  - System's size — $ Up to 50 m² > 50-100 m² > 100-500 m² > 500-1000 m² $

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Cash Flow Model for SHIP
Outflow - Operating Costs

- Comperatively low
  - Auxiliary for pumps & control is minimal
  - Technical & commercial management is not required
  - Regular maintanance & monitoring! -> 0.5 to 1% of the investment costs per year

Cash Flow Model for SHIP
Outflow - Capital Costs

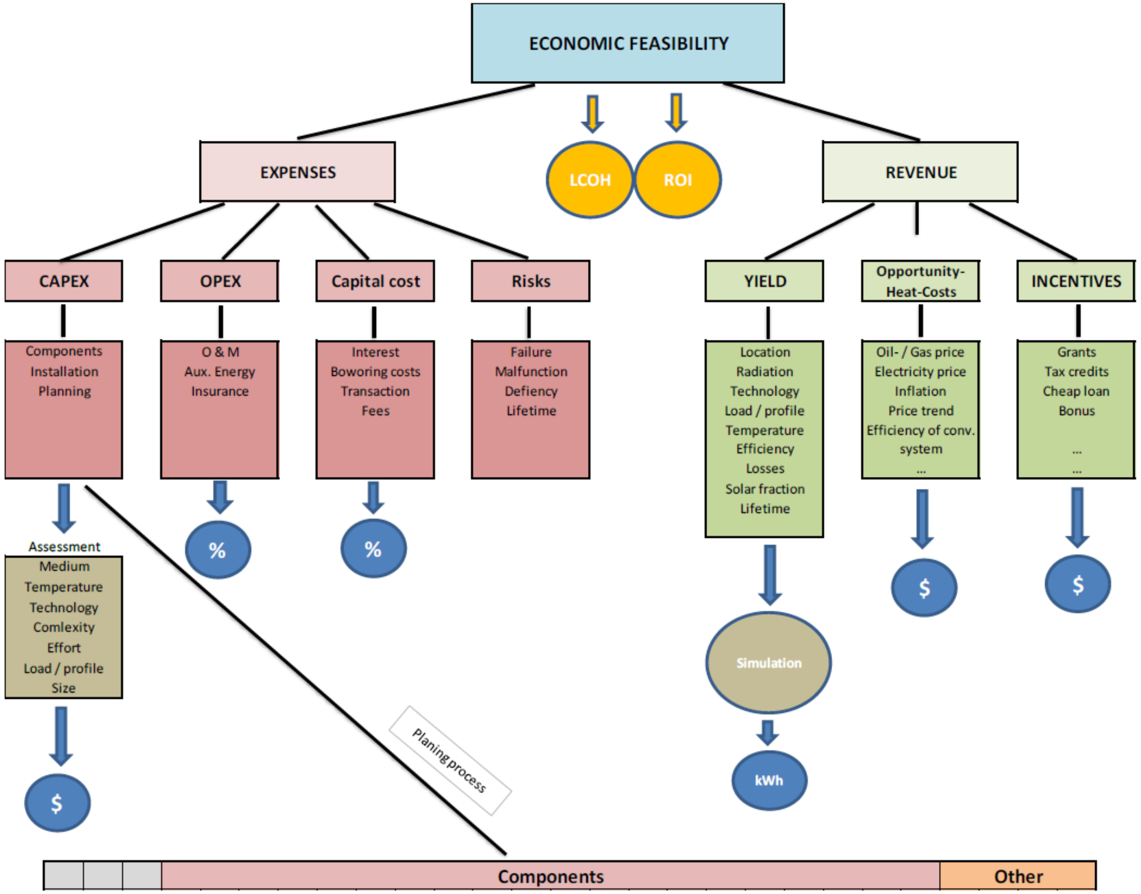
- interest rates payable to (debt) lenders
- required equity returns expected by (equity) investors

➨ Country specific risk
  - Political stability
  - Protection of investor’s property
  - Public debt rate
  - Credit rating

Cash Flow Model for SHIP
Risk evaluation

- Sources of risk
  - Supply side (revenue)
    - Energy yield
    - Pricing of conventional energy
  - Demand side
    - mis-specification of own future demand profile
- Risk of the investment's cash outflows
  - Investment – fixed in supplier/manufacturer contracts
  - Opex – minor impact
  - CoC - negotiated in financing & construction phase
- Corporate risk
  - already available to the investor's lenders
- Project risk
  - Installation, commissioning, operation
  - Technology risk

Financial parameters for SHIP
Input and Output parameters



[1]

[1] RENAC, 2017. Solar Payback: Interim Report: A financial business model for industrial solar thermal energy supplementation

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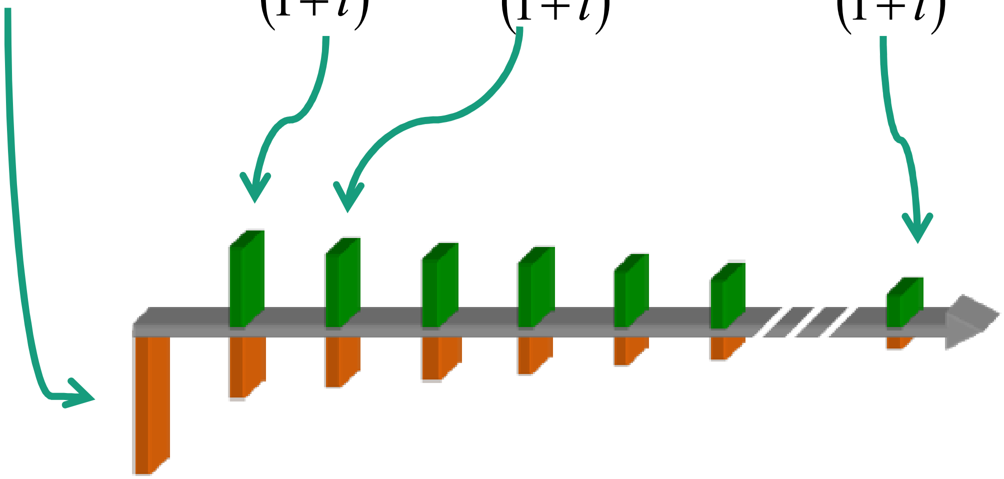
Financial parameters for SHIP
Assessment parameters - KPIs

- Payback time (statical, dynamical)
- Net present value (NPV)
- Internal rate of return (IRR)
- Levelized cost of heat (LCoH)
- …

Cash Flow Model
Inflows / Outflows

- Inflows and Outflows will be discounted to the year of investment

$$NPV = (ci_0 - co_0) + \frac{(ci_1 - co_1)}{(1+i)} + \frac{(ci_2 - co_2)}{(1+i)^2} + \ldots + \frac{(ci_t - co_t)}{(1+i)^t} = (ci_0 - co_0) + \sum_{t=1}^{n} \frac{(ci_t - co_t)}{(1+i)^t}$$



where:

ci_t = cash inflows in period t

co_t = cash outflows in period t

i = discount rate

n = number of analysis periods

Relevant KPIs
Net present value NPV

- Future capital flows will be discounted to the year of investment

$$NPV = I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+i)^t}$$

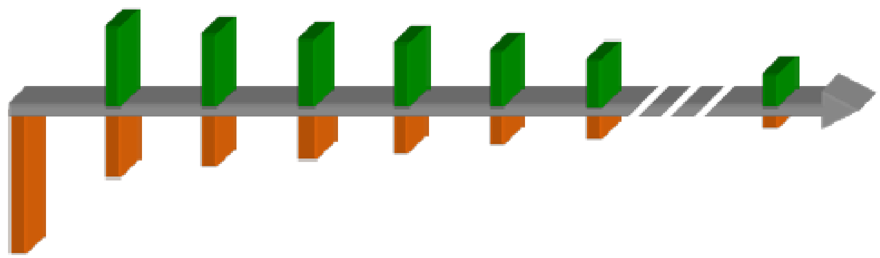
where:

I_0 = the initial capital investment in Period t=0 (<(

C_t = net cash flow in each subsequent period

i = discount rate

n = number of analysis periods



Assessment parameters - KPIs
Payback time

- Time required to recover the cost of investment
- The lower the payback time the better the investment
- Relates investment cost to annual cash flows

➢ Easy to understand

Simple Payback vs. Discounted Payback

Assessment parameters - KPIs

Levelized Cost of Heat (LCoH)

Investment of technology

Annual operation costs

- Fuel costs
- CO2 price
- Fixed and var costs

$$LCOH = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,th}}{(1+i)^t}}$$

Annual energy output

- Location
- System
- Degradation

Discount rate (WACC)

- Technology risk
- Investor expectation
- Region specific risk

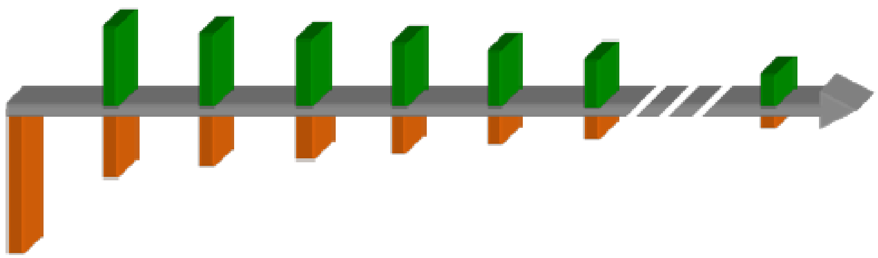
➢ Good for comparison of different energy sources

Assessment parameters - KPIs
Internal Rate of Return (IRR)

- IRR is interest rate for which NPV equals zero!

$$NPV = I_0 + \sum_{t=1}^{n} \frac{C_t}{(1+i)^t} = \mathbf{0}$$

IRR



Assessment parameters - KPIs
Internal Rate of Return (IRR)

- Project IRR
  - Inflow:

    full amounts of money needed in project
  - Outflow:

    cash generated by project
  - Assumption:

    No debt was used for the project

- Equity IRR
  - Inflow:

    = required cash flows – debt
  - Outflow:

    Cash flows from project – interest & debt repayment
  - "leveraged" version of IRR

[1] Infrastructure Project Finance , Amit Bhatia, 2013, Project IRR vs Equity IRR, http://infrastructure-projectfinance.blogspot.com/2013/11/project-irr-vs-equity-irr.html (online 13.11.2019)

Business Model for SHIP
Characterization

- fundamentally different temporal cost distribution compared to conventional heat generation technologies:
  - High costs at beginning
  - Low operational costs
  - ➡ Risk assessment has high impact on investment decision

Business Model for SHIP
Key actors

- Industrial company
- Financing party
- System provider
- Energy supplier

To be convinced by business model!

2 forms of Ownership

- Industrial company
  - Self-financing or third-party financier
  - Complete risk
  - Entire decision-making power
  - Solar thermal not core business -> Reluctance
- ESCO
  - Takes care of planning, financing and installation
  - Project and performance risk
  - Financing risk – depending on contract model

Business Model for SHIP
Driving forces

The implementation of a SHIP system usually is driven by the following:

- Elimination of fuel costs
- Reduction of risks associated with increasingly volatile and rising fuel prices
- Reducing carbon emissions
- Out-sourcing of non-core business

Business Model for SHIP
Three business models

- Differentiation of three business models according to the three main different services necessary to replace the costs of conventional heat by sustainable and renewable heat.

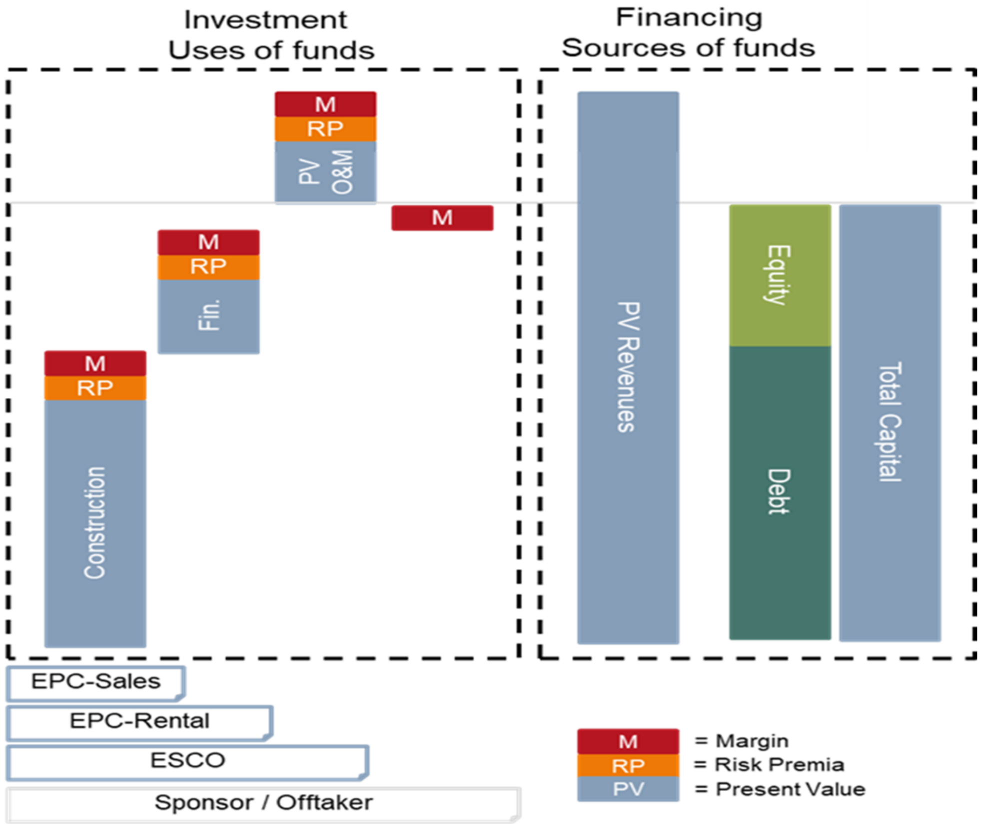
Construction	• **EPC - Sales Model** • Engineering, Procurement and Construction (EPC) for the technical implementation,
Financing	• **EPC – Rental Model** • For the financing of the initial investment costs of the renewable heat plant,
Operation	• **ESCO – Model** • Energy Servicing Company (ESCO) to operate the renewable heat plant during its life time.

[1]

[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Business Model for SHIP

Three business models



[1]

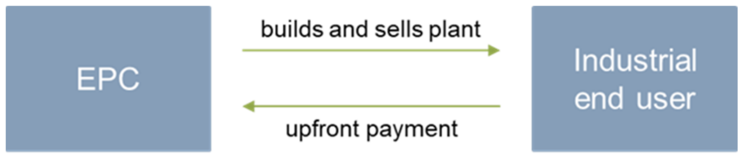
[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Business Model for SHIP

EPC – Sales model

Construction

- An engineering, procurement and construction (EPC)-contractor
  - purchases all necessary parts and services for commissioning of the plant and then transfers the plant to the client/off-taker.
  - takes all risks related to the construction phase and therefore requires a considerable margin on top of the pure margin-free investment costs.
- During construction or latest at commissioning the client pays the purchase price of the plant according to contractually agreed milestones. The financing of the purchase price rests with the client or heat consuming/off-taking company



[1]

[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Business Model for SHIP

EPC – Sales model

Construction

• Self-ownership of the asset	**Possible users**
• High initial investment cost • Full liability after expiry of manufacturer‘s warranties • Internal expertise and resources for system operation required	Companies with sufficient internal resources to finance the purchase price (on-balance) and operate the plant

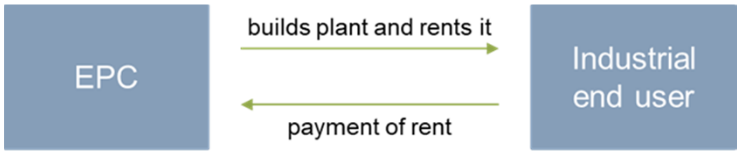
[1]

[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Business Model for SHIP
EPC – Rental model

Financing

- An engineering, procurement and construction (EPC)-contractor
  - Not only builds the plant but also raises the necessary funds to finance it most likely on his own balance sheet
- Instead of receiving a purchase price for the plant from the off-taker at commissioning, the EPC will own the plant and charge the off-taker a continuous rental payment for using the plant.
  - This rental payment covers of course at least the EPC's (re-)financing costs as well as risk premia, and additional upfront and running margins.



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[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

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Business Model for SHIP

EPC – Rental model

Financing

+ / –	Possible users
• No initial investment cost	Companies lacking the ability to finance the initial investement costs.
• High leasing fees • Internal expertise and resources for system operation required	

[1]

[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Business Model for SHIP
ESCO

Operation

- The energy servicing company (ESCO) provides the service to operate the renewable plant that generates the heat delivered to the off-taker.
- The ESCO may be able to offer long-term price stability and thereby stabilize the potential future value added of the off-taker as his costs of heat become more stable and plannable.
- The major cost component of the renewable heat is initial investment cost (CapEx) annualized into interest- and re-payment that are mostly fixed.
- The ESCO will charge his original cost of operation (i.e. the plant's OpEx) plus a profit margin and risk premia to cover all risks related to the operation of the plant.

Business Model for SHIP
Energy Service Company ESCO

Operation

- No initial investment cost
- All inclusive package – no profound expertise on the off taker's side needed

- All-in service is reflected in the price of the heat.

Possible users

Companies that outsource the operation of the plant and favor a simple but more expensive and less profitable solution.

[1]

[1] RENAC, 2018. TrustCS: Business models suitable for the solar heat market in the industrial sector in Mexico

Current state in Brazil

- High taxes on imported products
- SHIP raplaces:
  - Gas – absence of networks
  - Biomass (bagasse) – constraints in use of fresh wood
  - LPG – price fluctuations
- GHG emissions
  - Government is in the process of introducing market instruments to reduce GHG emissions
- Certifications
  - certification of equipment manufacturers introduced
  - High costs -> threat to small manufacturers
  - absolutely necessary for the development of the market, as generally accepted standards give banks and investors security
- ESCOs
  - ESCO association ABESCO since 1997
  - 35% of ESCO's target groups in industry
  - Not familiar with SHIP

Current state in Brazil
Support Policies

- The energy efficiency promotion is mainly dedicated to the electricity sector (not solar thermal)
  - Around the world, national programmes on energy efficiency often include solar thermal technology

- Selection of programmes and financing institutions to promote efficiency:
  - PROCEL, CT-ENERG, PEE, FNMC, BNDES
  - Focus on electricity saving measures and therefore not suitable for SHIP

➢ **Need for dedicated funding and credit lines for SHIP investments**

[1]

[1] Solar Payback 2018, Energia Termossolar para a Indústria: Brasil, https://www.solar-payback.com/potencial/

Current state in Brazil
Key actions

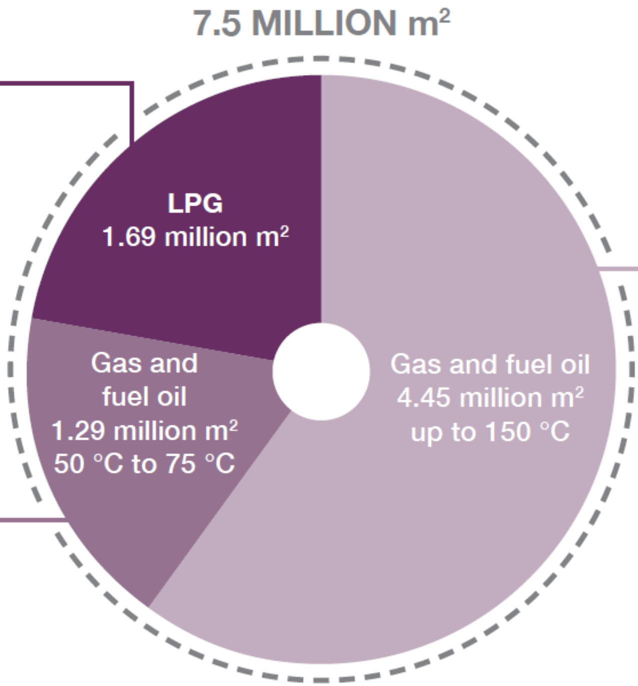
Three key actions are needed to implement the Industrial Solar Heat Strategy

Profitability even without support

Profitability with international financing

Profitability with international financing and local collector production

RAISE AWARENESS among industrial costumers, because SHIP is already cost competitive for many factories (especially LPG driven processes), but is not known well enough yet.

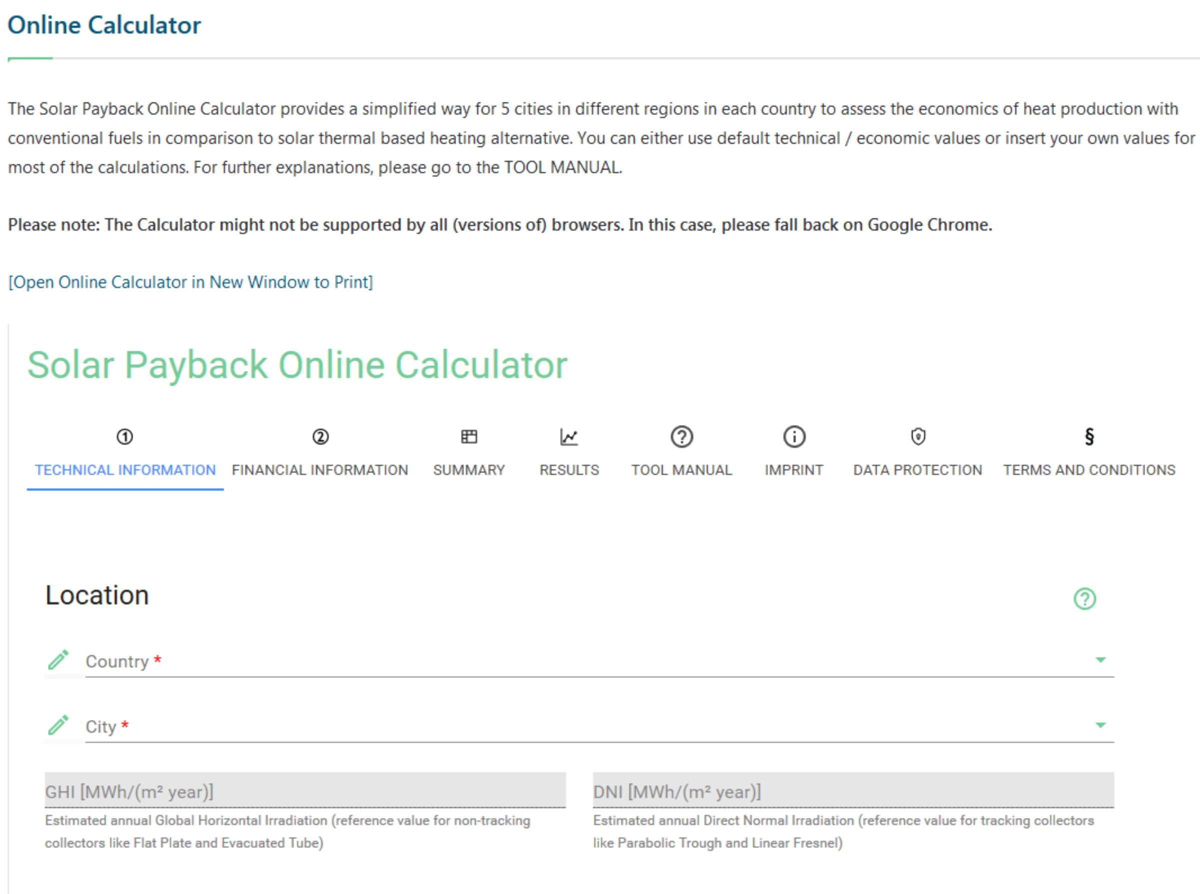


PROVIDE LOW INTEREST LOANS (4%) via Fundo Clima with the support of international financing for factories that use natural gas and fuel oil.

ENCOURAGE LOCAL PRODUCTION of concentrating collectors to bring down CAPEX of SHIP systems for process temperatures up to 150 °C.

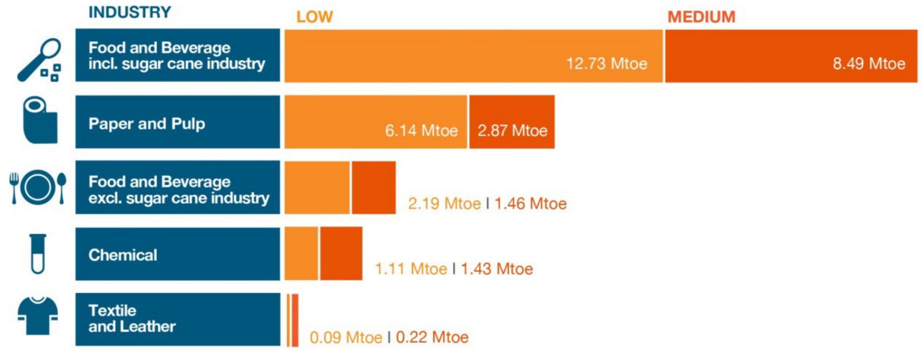
Solar Payback Online Calculator

https://www.solar-payback.com/calculator



Solar Payback Online Calculator
Exercise

- Annual Heat Demand



Greater competitiveness in three key industrial sectors

Potential SHIP users can be found in the dynamically growing pulp and paper, food and beverage, and chemical industries.

INDUSTRIES	NO. OF BUSINESSES IN THE 10 MOST POWERFUL STATES ECONOMICALLY	HEAT DEMAND MET BY FOSSIL FUELS Low-temp (< 150 °C)	INCREASE IN HEAT DEMAND BETWEEN 1996 AND 2016
PULP & PAPER	4,960	716 ktoe	146%
FOOD & BEVERAGE	45,865	751 ktoe	13%
CHEMICALS	8,727	596 ktoe	24%

per company:

Ø **1700 MWh/a**

Source: EPE 2017 / CNI 2015 / IBGE 2015

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Solar Payback Online Calculator
Exercise

- Energy Price:

LPG | Fuel/Oil | Gas

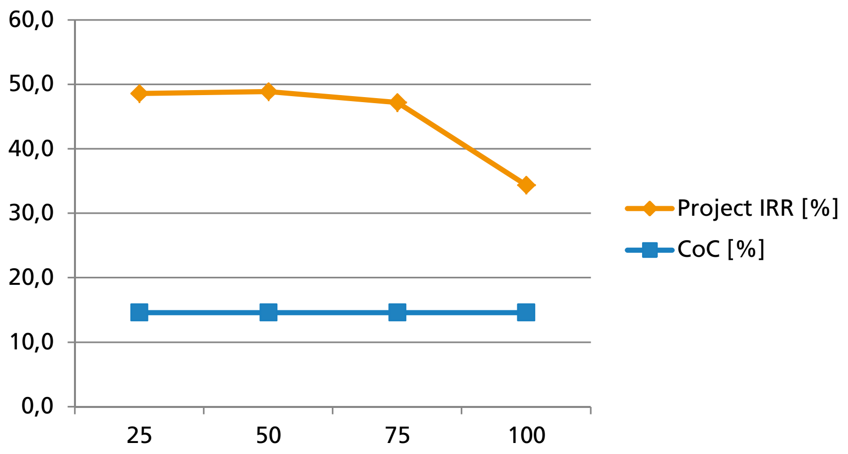
FUEL	FUEL OIL PRICES INCL. TAX (2,000 m³ of natrual gas a day)	AVERAGE
Gas	165 to 275	220 BRL/MWh
Fuel/Oil	218 to 258	238 BRL/MWh
LPG	495 to 597	546 BRL/MWh

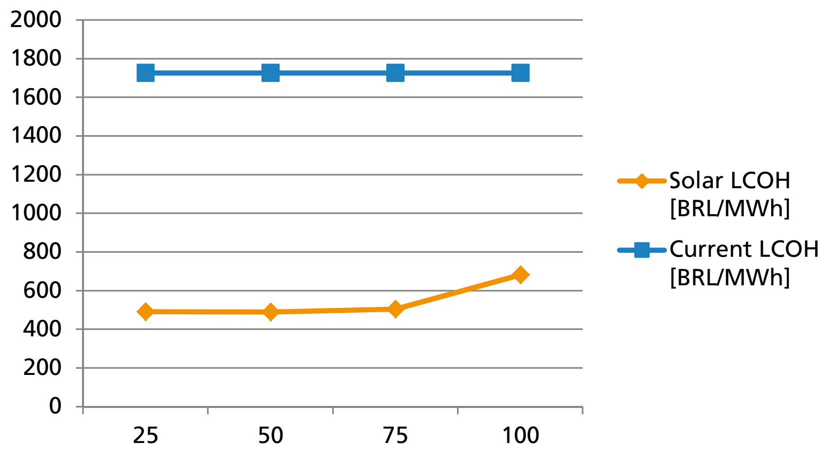
[1]

[1] MEE 2018 / Sindigás 2018

Solar Payback Online Calculator
Exercise

- Task 1a
  - FPC at 50°C





  - Project is feasible (project IRR > CoC) with a good project IRR of 48,9% (TES=50l/m²)
  - The solar LCOH comes to 490 BRZ/MWh vs. Current LCOH of 1726 BRZ/MWh

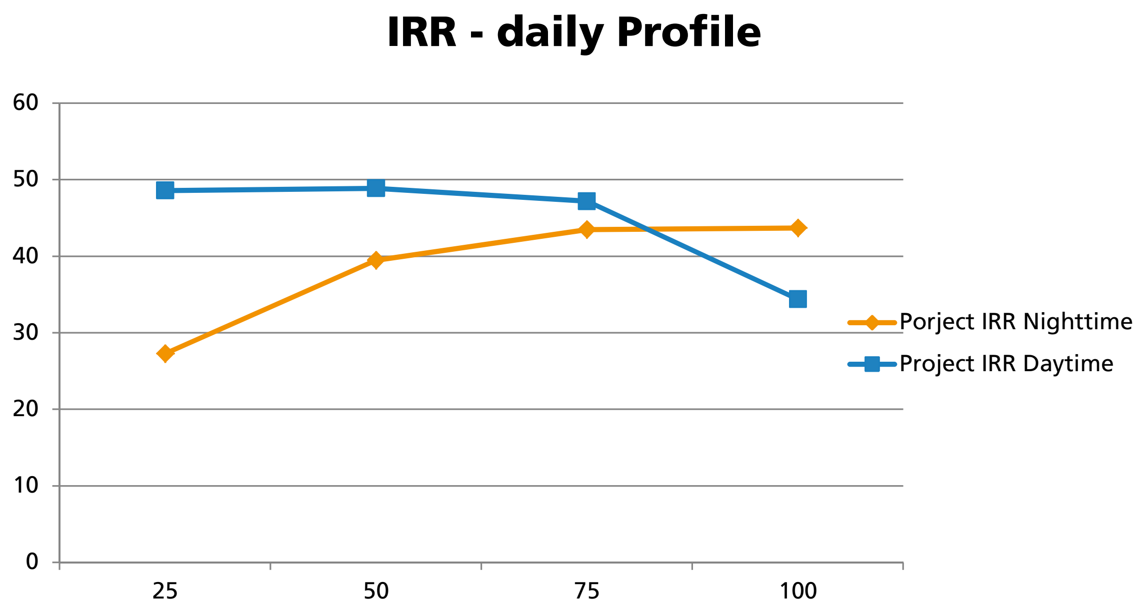
Solar Payback Online Calculator
Exercise

- Task 1a
  - FPC at 50°C

Storage size [l/m²]	Solar yield [MWh/year]	Invest cost [BRL]	NPV project margin [BRL]	Project IRR [%]	Simple Payback [years]	Discounted Payback [years]	Solar LCOH [BRL/MWh]	Current LCOH [BRL/MWh]	CoC [%]
25	496,7	1102383	3922791	48,6	1,4	2,1	492	1726	14,6
50	573,3	1263967	4537020	48,9	1,4	2,00	490	1726	14,6
75	620	1425550	4846822	47,2	1,5	2,20	505	1726	14,6
100	463,3	1587133	3092047	34,4	2,6	3,90	683	1726	14,6

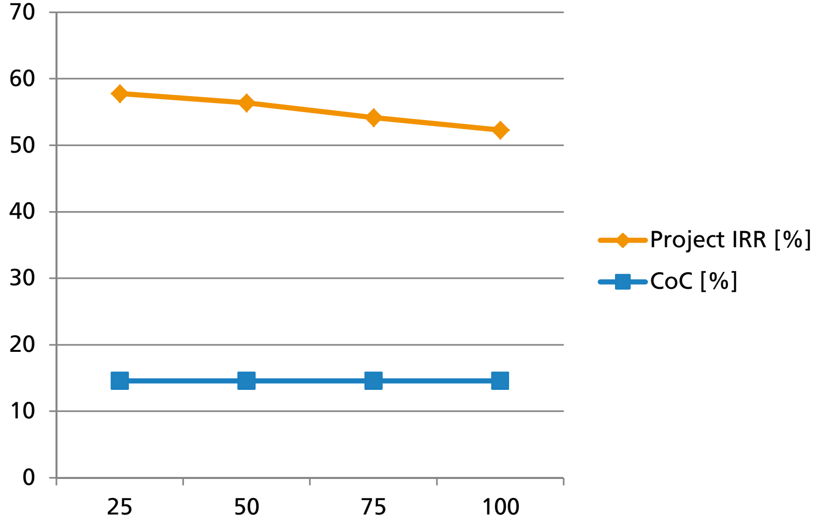
Solar Payback Online Calculator
Exercise

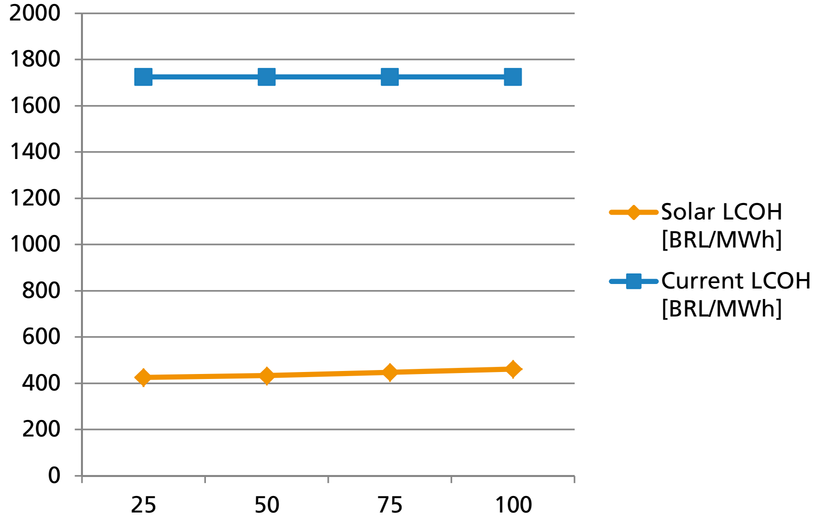
- Task 1a – Daytime vs. Nighttime
  - FPC at 50°C



Solar Payback Online Calculator
Exercise

- Task 1a
  - ETC at 50°C

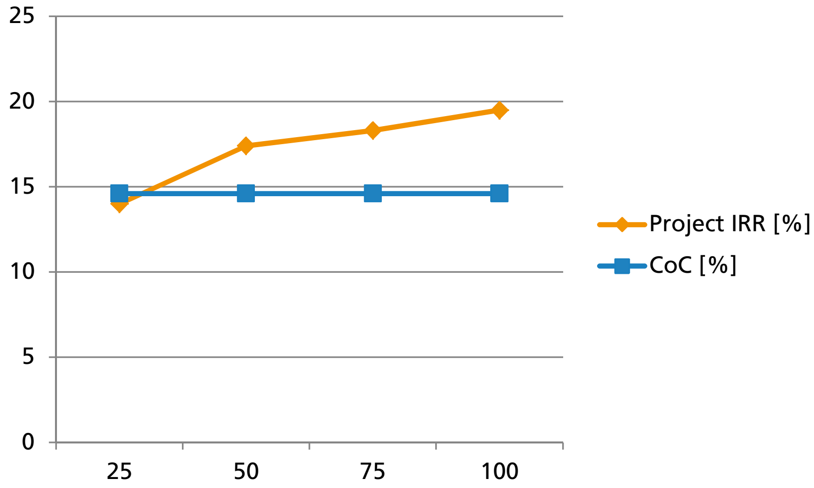


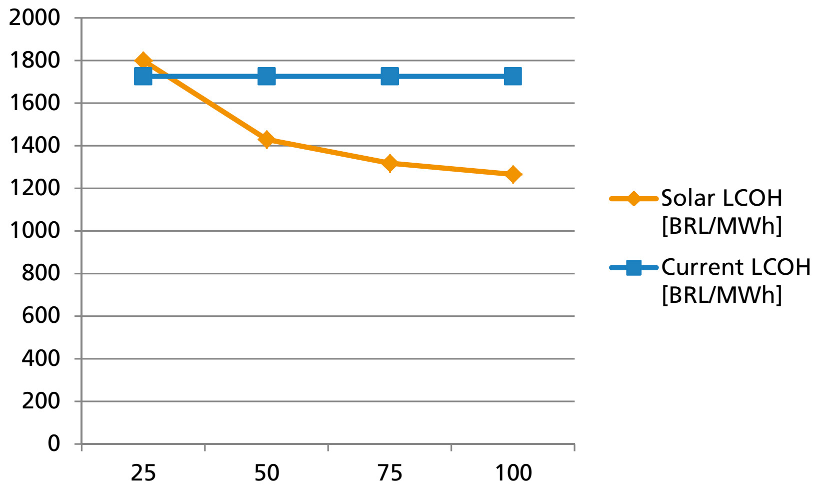


  - Project is feasible (project IRR > CoC) with a good project IRR of 57,8% (TES=25l/m²)
  - The solar LCOH comes to 426 BRZ/MWh vs. Current LCOH of 1726

Solar Payback Online Calculator
Exercise

- Task 1b
  - PTC at 150°C





  - Project becomes feasible with a big storage (TES=100l/m²) at a project IRR of 19,5%
  - The solar LCOH comes to 1266 BRZ/MWh vs. Current LCOH of 1726

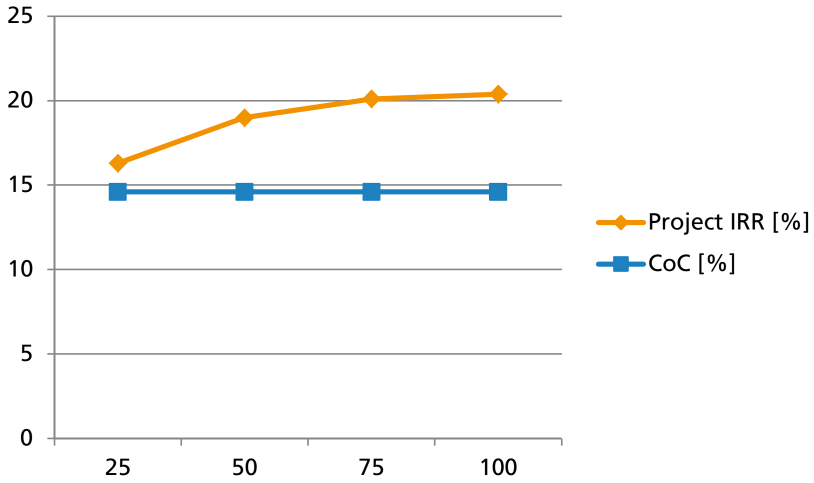
Solar Payback Online Calculator
Exercise

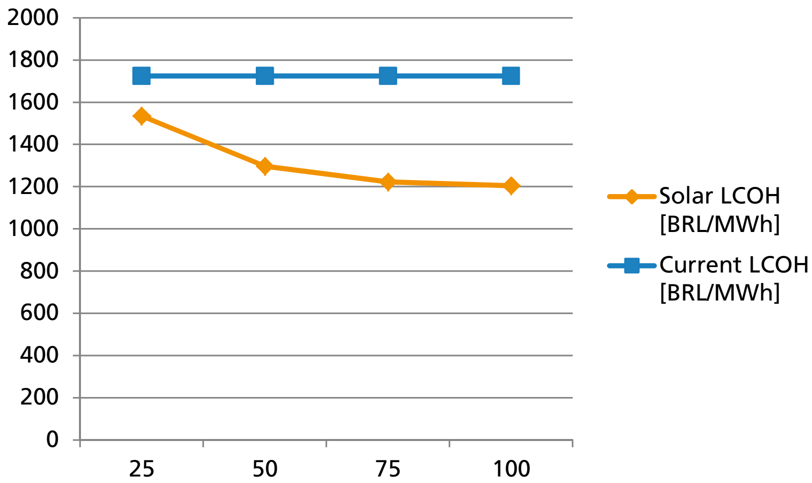
- Task 1b
  - PTC at 150°C

Storage size [l/m²]	Solar yield [MWh/year]	Invest cost [BRL]	NPV project margin [BRL]	Project IRR [%]	Simple Payback [years]	Discounted Payback [years]	Solar LCOH [BRL/MWh]	Current LCOH [BRL/MWh]	CoC [%]
25	178,4	1846068	-83531	14	7,6	19	1800	1726	14,6
50	243,2	1962408	461435	17,4	6,2	13,2	1430	1726	14,6
75	281,6	2078748	734365	18,3	5,7	11,6	1319	1726	14,6
100	311,2	2195088	917184	19,5	5,5	10,8	1266	1726	14,6

Solar Payback Online Calculator
Exercise

- Task 1b
  - LFR at 150°C





  - Project is feasible with a project IRR of up to 20,4% (TES=100l/m²)
  - The solar LCOH comes to 1205 BRZ/MWh vs. Current LCOH of 1726

Solar Payback Online Calculator
Exercise

- Task 1b
  - LFR at 150°C

Storage size [l/m²]	Solar yield [MWh/year]	Invest cost [BRL]	NPV project margin [BRL]	Project IRR [%]	Simple Payback [years]	Discounted Payback [years]	Solar LCOH [BRL/MWh]	Current LCOH [BRL/MWh]	CoC [%]
25	296,3	2584181	361529	16,3	6,6	14,7	1536	1726	14,6
50	381,3		1044268	19	5,6	11,3	1298	1726	14,6
75	433,7	2947744	1393923	20,1	5,3	10,3	1224	1726	14,6
100	468,8	3129525	1564378	20,4	5,2	10,1	1205	1726	14,6

Solar Payback Online Calculator
Exercise

- Task 2a
  - PTC at 150°C
  - Storage size =100 l/m²
  - Fuel price = 230 BRZ/MWh
  - Investment Costs = 2,405,970 BRZ

  - The project does not reach feasibility. The project IRR comes to 9,9%

Solar Payback Online Calculator
Exercise

- Task 2b
  - PTC at 150°C
  - Storage size =100 l/m²
  - Fuel price = 230 BRZ/Mwh
  - Investment Costs = 1,809,000 BRZ (33% import tax off)

  - The project does still not reach feasibility. The project IRR comes to 13,1%

Solar Payback Online Calculator
Exercise

- Task 2c
  - PTC at 150°C
  - Storage size =100 l/m²
  - Fuel price = 230 BRZ/Mwh
  - Investment Costs = 1,809,000 BRZ (33% import tax off)
  - Debt rate = 4%

➨ CoC = 6,5%, the project IRR reaches 12,5%

➨ Current LCOH = 908 BRZ/MWh ↔ Solar LCOH = 592 BRZ/MWh

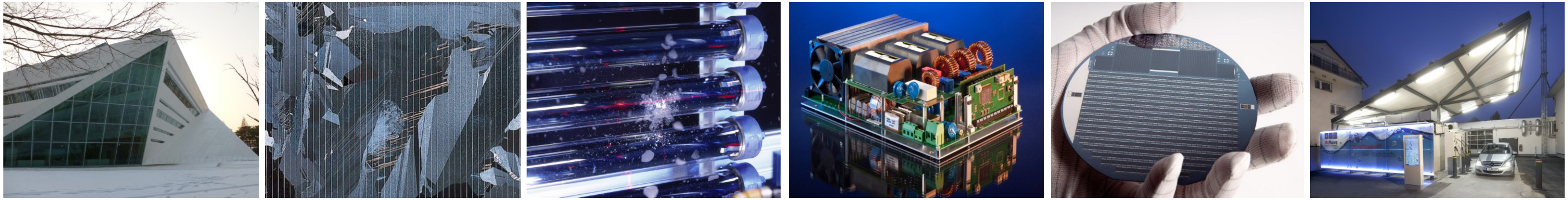
Solar Payback Online Calculator
Exercise

- Task 2

LPG price [BRZ/MWh]	debt rate [%]	Storage size [l/m²]	Solar yield [MWh/year]	Invest cost [BRL]	NPV project margin [BRL]	Project IRR [%]	Simple Payback [years]	Discounted Payback [years]	Solar LCOH [BRL/MWh]	Current LCOH [BRL/MWh]	CoC [%]
550	13,33	100	389	1809000	2109110	27,1	3,6	6,1	879	1726	14,6
230	13,22	100	389	1809000	-206764	13,1	8,1	19	805	722	14,6
230	13,22	100	389	2405970	-830089	9,9	10	19	1055	722	14,6
230	4	100	389	2405970	769620	9,3	10	14,3	728	**908**	**6,5**
230	4	100	389	1809000	1352823	12,5	8,1	11	592	**908**	**6,5**

- CoC and Current LCOH are affected by debt rate

Thank you for your Attention!



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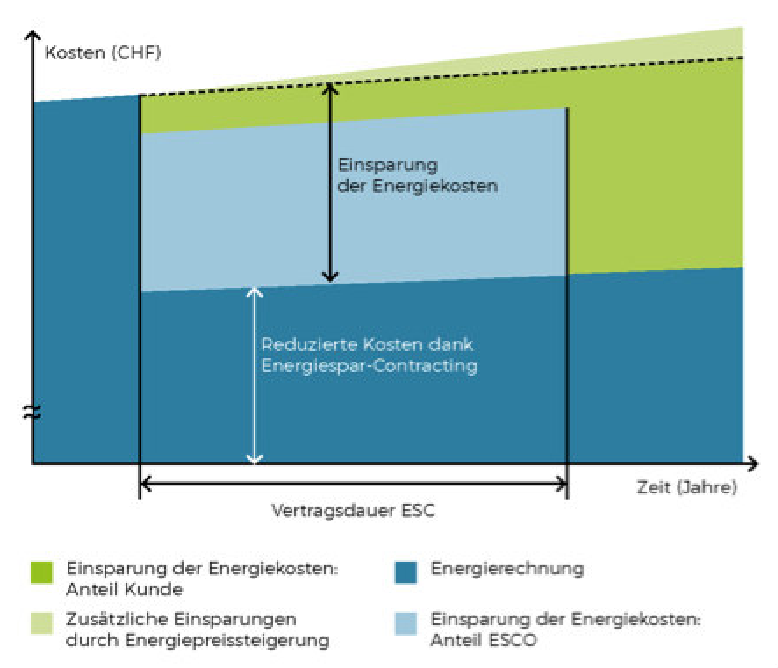
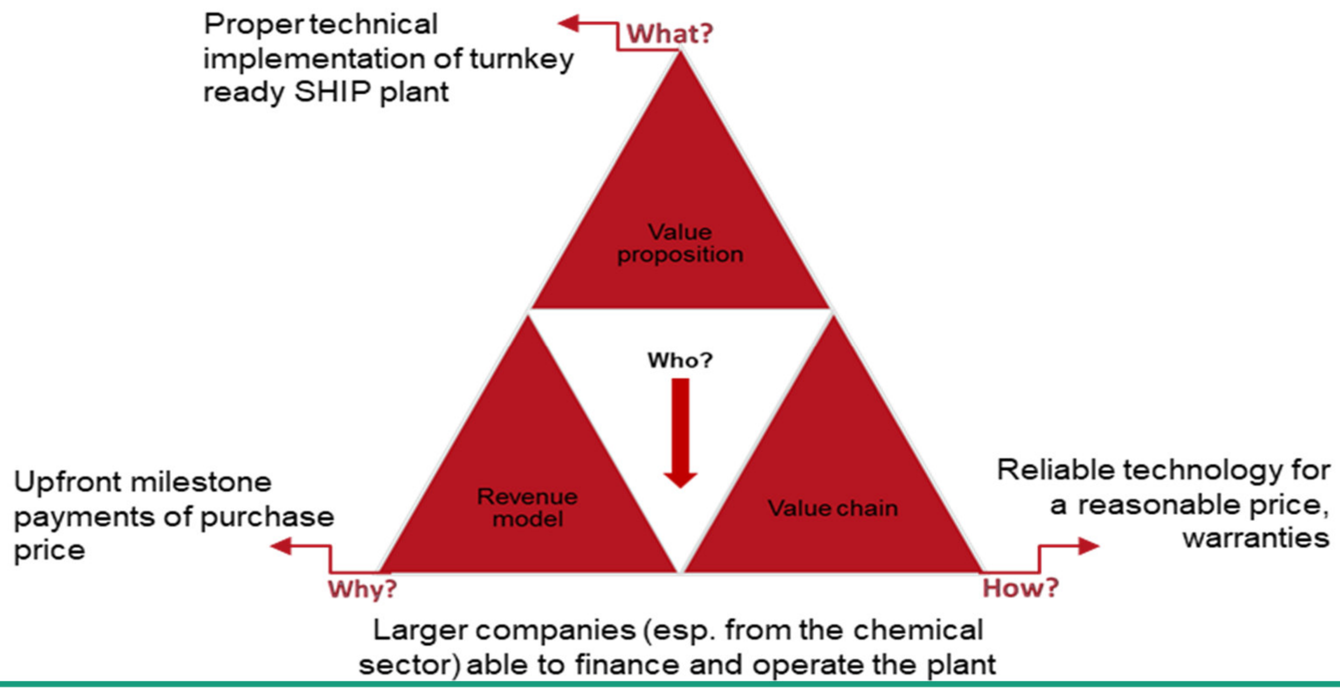

Kosten (CHF)
Einsparung
der Energiekosten
Reduzierte Kosten dank
Energiespar-Contracting
Zeit (Jahre)
Vertragsdauer ESC
Einsparung der Energiekosten:
Anteil Kunde
Energierechnung
Zusätzliche Einsparungen
durch Energiepreissteigerung
Einsparung der Energiekosten:
Anteil ESCO

Standardized description of business models with the St. Gallen Business Model Navigator (BMN)

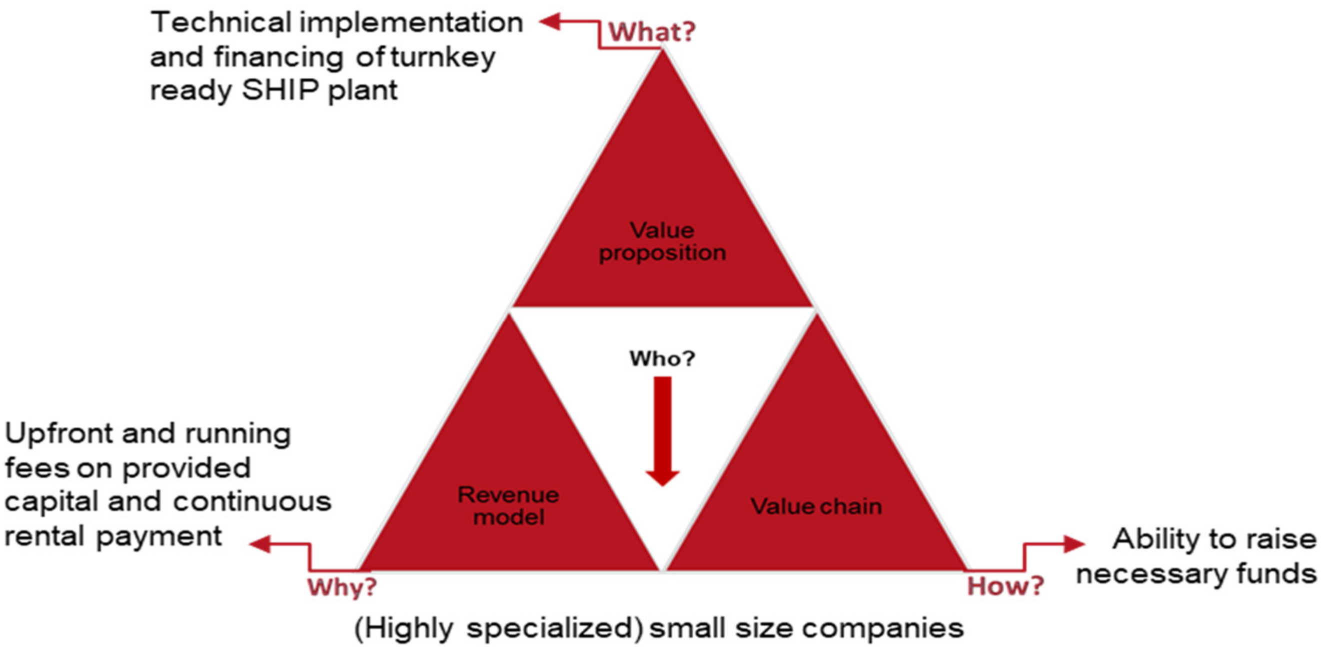
Standardized description of three business models from a metaperspective using four dimensions: the Who, the What, the Value and the Why

- **Who** are the business‘s target customers?
- **What** kind of value proposition does the business offer its customers?
- **How** does the business model create **value** for its customers?
- **Why** does the business model generate profit?

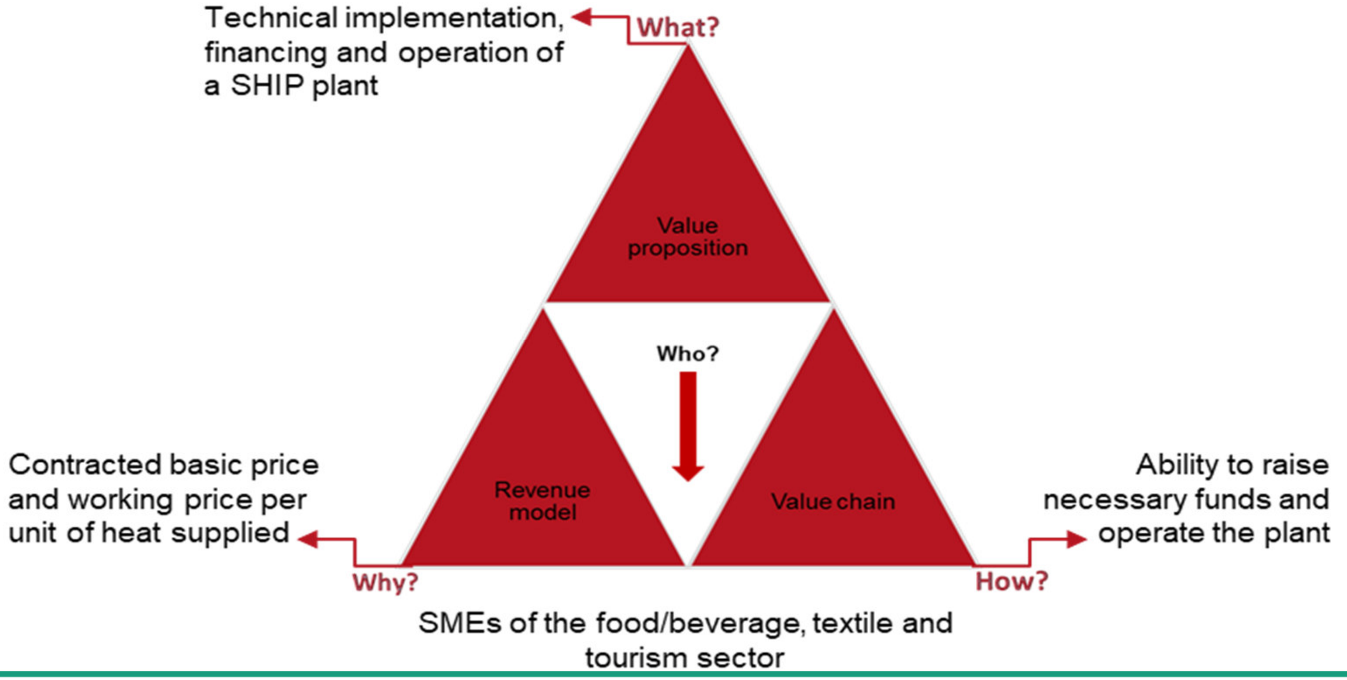
Turnkey supplier - EPC Sales model



Turnkey supplier - Rental model



ESCO model

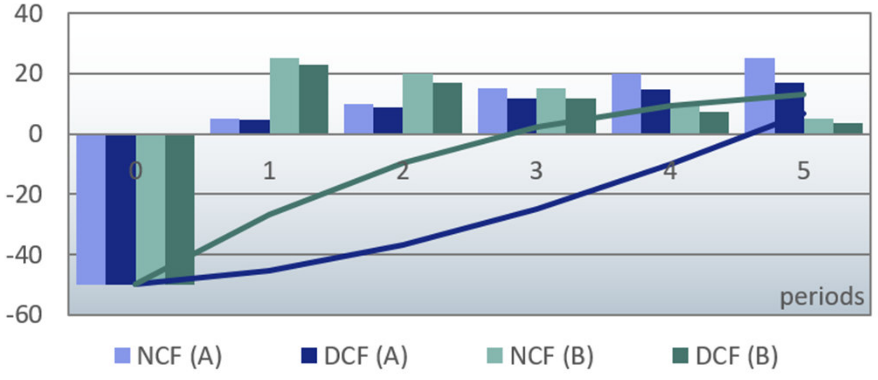

Technical implementation, financing and operation of a SHIP plant
What?
Value proposition
Who?
Revenue model
Value chain
Contracted basic price and working price per unit of heat supplied
Why?
Ability to raise necessary funds and operate the plant
How?
SMEs of the food/beverage, textile and tourism sector

Cash Flow Model

Example of NPV calculation of two almost similar projects

Discount rate = 8%

Period *t*	0	1	2	3	4	5	Total
Net Cash Flows Alternative A	-50	5	10	15	20	25	25
Net Cash Flows Alternative B	-50	25	20	15	10	5	25
Discounted Cash Flows Alternative A	-50	4.6	8.6	11.9	14.7	17.0	6.8
Discounted Cash Flows Alternative B	-50	23.1	17.1	11.9	7.4	3.4	13.0



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