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Cost, energy and climate performance assessment of Split-type ACs in Asian countries

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On behalf of:
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany

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Background and Objective

- Split-type Air Conditioners (Split ACs) are responsible for largest share of energy consumption and GHG in RAC in many countries worldwide.
- Barriers include decision maker’s (policy, consumers) little knowledge about the energy and cost efficiency of split-type ACs
- Objective of the study is to provide an **overview of energy and cost efficiency, climate impact of split-type ACs** in selected partner countries.
- The results and recommendations shall help policy makers to undertake informed decision making towards more efficient and climate-friendly split AC.

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Background and Objective

- Analysis of over **1,460 split type AC units** across **67 local and international brands** in 9 GIZ Proklima partner countries in Africa, Latin America, Middle East and South East Asia
- Assessment of commonalities and differences of split AC markets among countries
- Analysis of relationship between energy efficiency and market prices, share of technology type (inverter / fixed speed) and refrigerants used
- Recommendations on improving Minimum Energy Performance Standards (MEPS) and transitioning to appliances with improved energy efficiency and low GWP refrigerants

Methodology

- Collection of split AC-related key data in electronic stores, brand stores and online shops in each country in order to calculate:
  - National average energy efficiency in relation to current MEPS regulation
  - Life cycle costs of split AC
  - Total Equivalent Warming Impact (TEWI)

- Data sample collected from December 2017 to March 2018.


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Key parameters

Source: GIZ Proklima 2018

Country	Sample size	Cooling Capacity in kW, units per class	Capacity classes selected	Inverter share	Discount rates (%)	Electricity Tariff (USD/kWh)	Runtime (hrs./year)	Grid Emission Factor (CO2)
Grenada	24	2-4 , 9 units 4-6, 8 units	3 kW 5 kW	85% AC VSD 15% Fix	5,00%	0.310	2,920	0.634
Vietnam	78	2-3, 30 units 3-4, 37 units	2,5 kW 3,5 kW	77% DC VSD 13% Fix	6,25%	0.08	3,695	0.572
Philippines	441	2-3, 227 units 3-4, 159 units	2.5 kW 35 kW	89% DC VSD 11% Fix	3,00%	0.188	3,745	0.526
Indonesia	144	1 -2, 55 units 2 - 3, 68 units 3 - 4, 21 units	1,5 kW 2,5 kW	59% DC VSD 41% Fix	4,00%	0.094	3,434	0.827
Iran	370	2 - 4, 136 units 4 - 6, 96 units 6 - 8, 96 units	3 kW 5 kW 7 kW	8% Inverter 92% Fix	18,00%	0.009	2,555	0.7
Thailand	62	2 to 3, 19 units 3-4, 18 units 5-6, 18 units	3 kW 4 kW 5 kW	11% Inverter 89% Fix	1,50%	0.134	3,434	0.572
Ghana	93	3 - 4, 52 units 5- 6, 30 units 6 - 7, 29 units	3,5 kW 5 kW 7 kW	53% DC VSD 47% Fix	18,00%	0.14	1,919	0.39
Colombia	93	2 - 3, 61 units 3- 4, 73 units 5 - 6, 33 units >7, 24 units	2,5 kW 3,5kW	73% Inverter 27% Fix	5,00%	0.12	1,098	0.374
Costa Rica	159	2 to 3, 26 units 3 to 4, 47 units 5 to 6, 40 units 6 to 7, 38 units >7, 8 units	3,5 kW 5 kW 7kW	90% inverter 10% Fix	5,00%	0.243	883	0.064

Sources: Discounts: The interest rates for the life cycle value of the product (https://tradingeconomics.com/country-list/interest-rate?continent=asia) Electricity Tariff: country database

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Methodology and assumptions

- **2-3 capacity classes** with the highest distribution of appliances were selected for each country
- Energy efficiency is uniformly shown in EER*
- For the refrigerant emission analysis, the following assumptions are used
  - Annual leakage rate (ALR) = 5%
  - End of life emissions (EOL) = 95 %
- Energy efficiency categorization:
  - Energy efficiency (EE) was categorized in the country analysis with **lower** (<3.5) **and higher EE** (>3.5)
  - EER 3.5 defines “no regret” level, as it is higher or at the same level of current MEPS and (average) LCC lower for all countries
  - A MEPS of EER 3.5 has advantages for all countries and end consumers due to lower emissions and LCCs

Higher EE

Lower EE

*** Energy efficiency is uniformly shown in EER applying a simplified conversion factor EER = SEER / 1,2 for countries where SEER data was present** ***Source: SEER conversion:*** ***https://www.nrel.gov/docs/fy11osti/49246.pdf; https://en.wikipedia.org/wiki/Seasonal_energy_efficiency_ratio; http://www.fsec.ucf.edu/en/publications/html/FSEC-PF-413-04/***

Limitations

- Data sample size varies from country to country
- Data collection only during a defined period of four months
- Appliances offered in selected consumers stores do not necessarily indicate the representative market share of a model (e.g. units sold in ‘B to B’ might contain additional models and different inverter /fix-speed ratio)
- Efficiency metrics were converted for inverter splits from SEER to EER to allow comparison (which is an approximation given differences in test conditions and measured temperature bins across countries)
- Missing key countries (e.g. India, China) still missing yet, but will be included

Key Findings

- Large differences between countries (average per country according to sample for 3-4 kW splits)
  - **Total Equivalent Warming Impact** (TEWI) from 6 - 77 t CO_2 eq per appliance
  - **Energy Efficiency Ratio** (EER) per country from 3 to 4.3
  - **Unit price** from 367 to 760 USD
  - **Lifecycle Costs** (LCC) from 815 to 15,740 USD

- While countries with higher EER don't have the highest unit prices, countries with low unit price have lower EER
- In all countries units with EER >3.5 have lower LCC than units with lower EERs, suggesting that **MEPS can and should be set above 3.5 across all countries**

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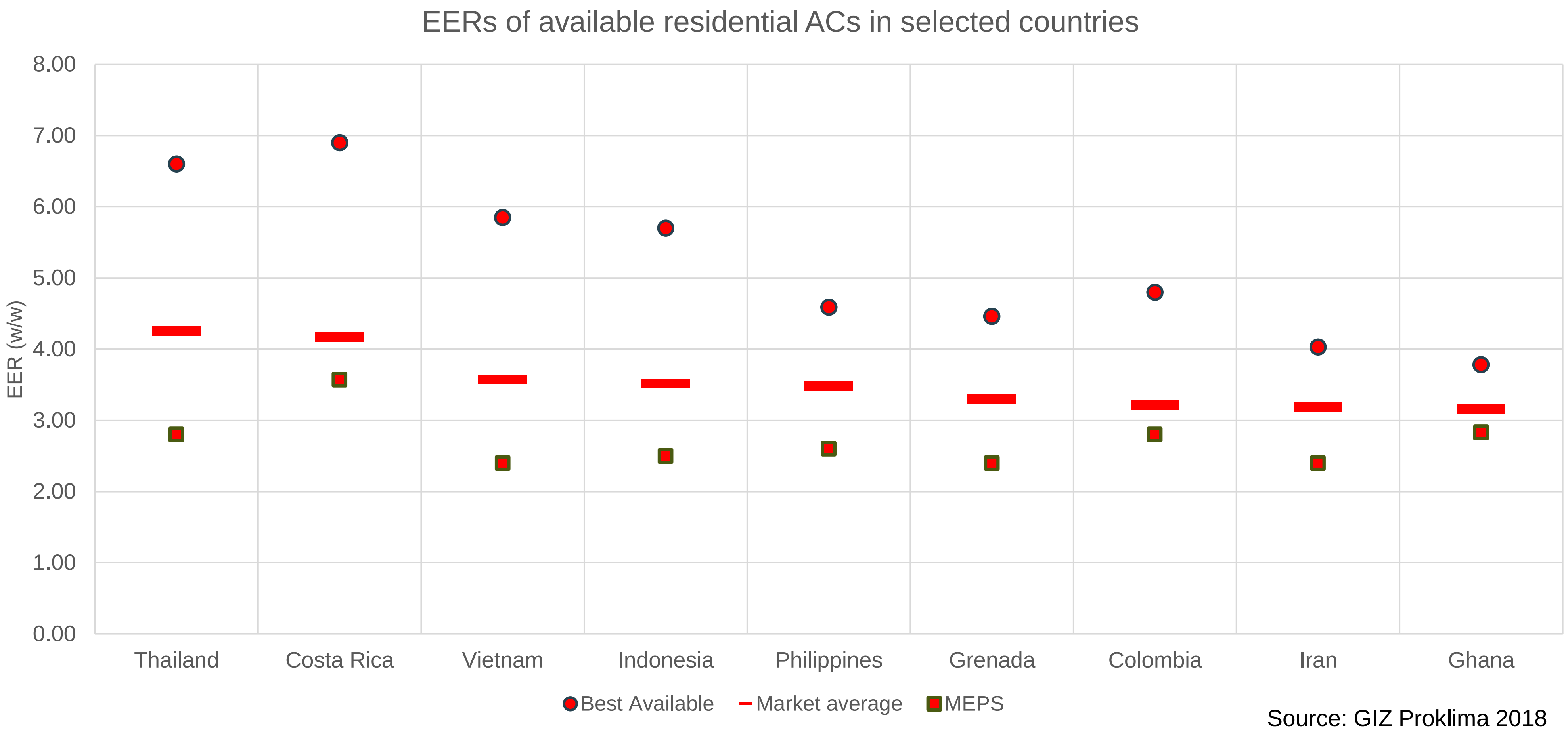
Key Findings (2)

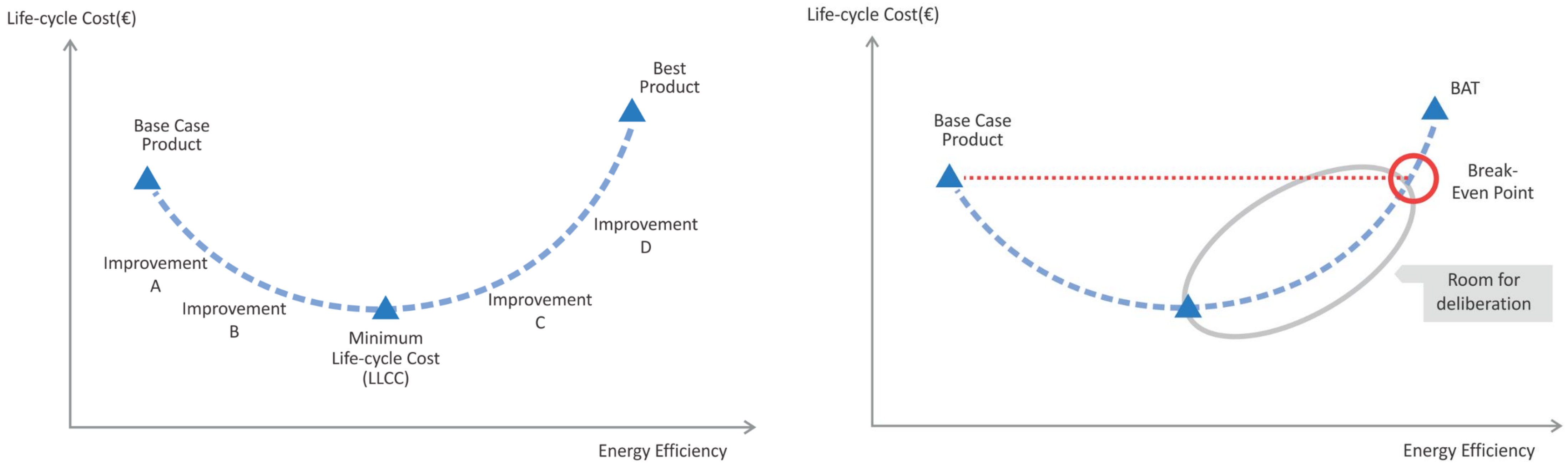
- EER and LCC: Upfront prices are only a small portion of LCC in most countries, therefore high energy efficiency units will lower the total LCC.
- In countries with highly subsidized electricity and low LCC, upfront prices matter more, so low electricity prices are a barrier to higher energy efficiency.
- Most of the countries use R22, R410a and increasingly R32 as refrigerants, indicating huge potential for more climate-friendly refrigerants.
- In some countries, sold units range below the MEPS, raising questions of regulatory compliance.

Efficiency of split ACs



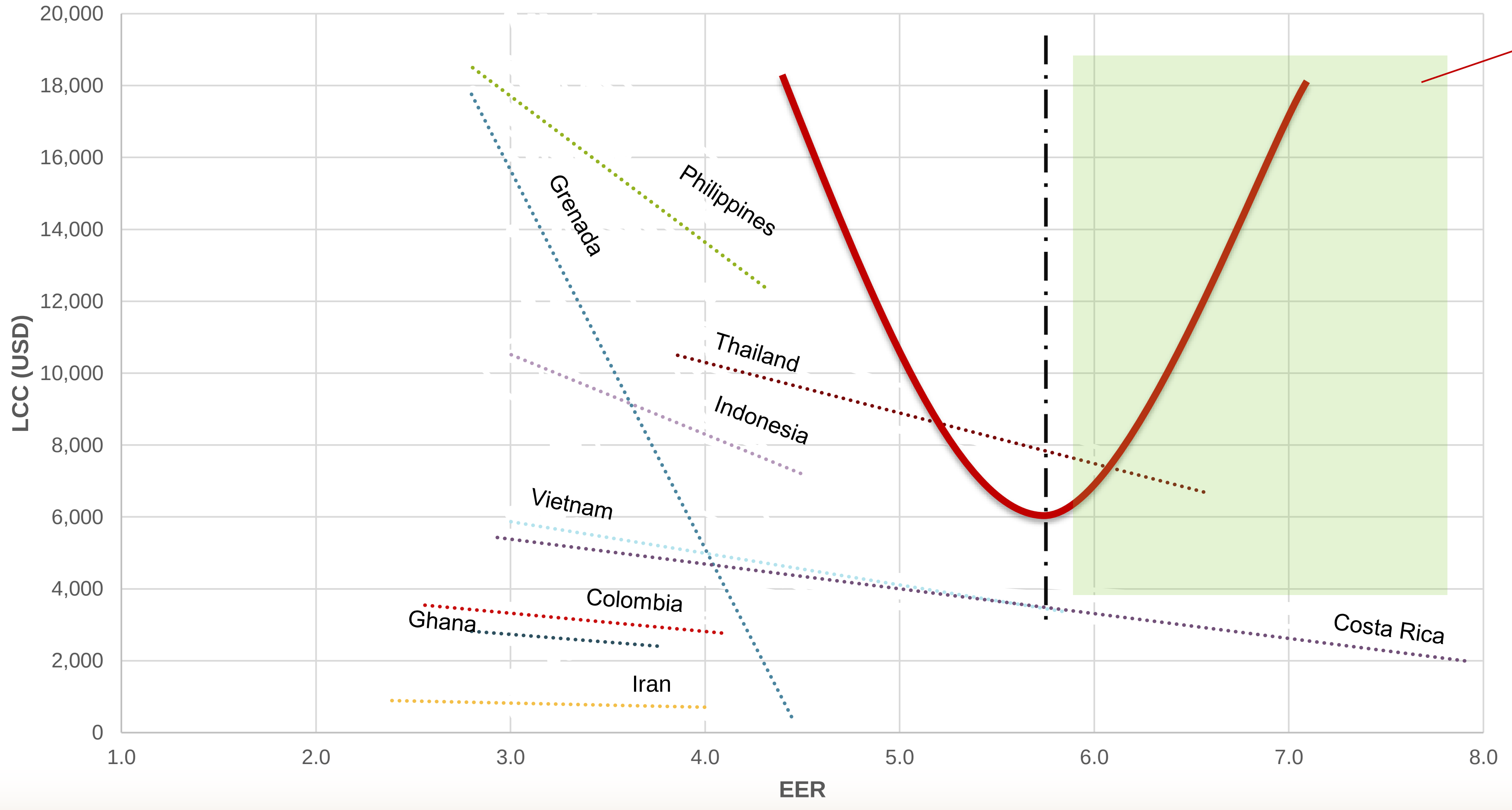
Source: GIZ Proklima 2018

Cost effectiveness of split ACs



Source: Coolproducts.eu (2013). Improving on the Least Life Cycle Cost criterion for a doubling of energy savings

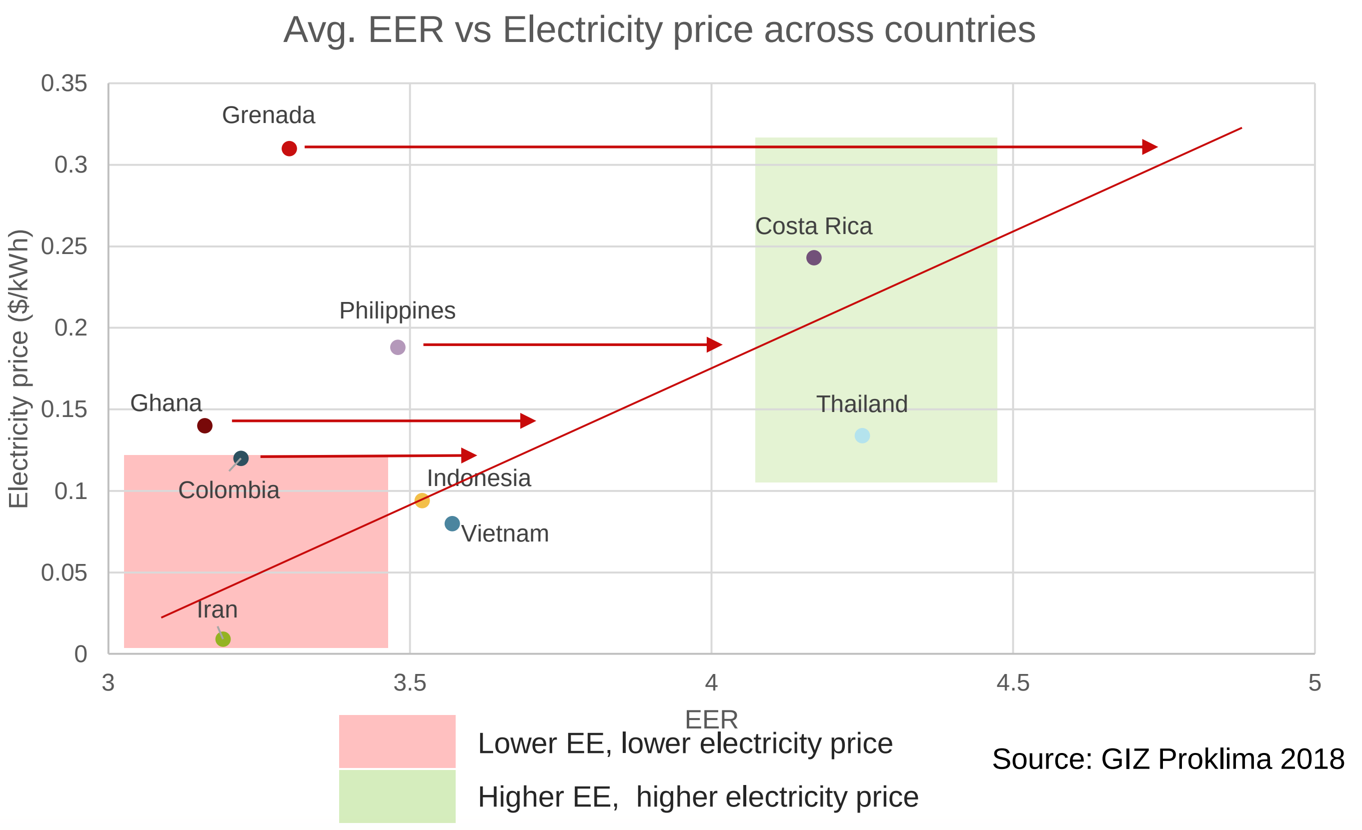
Cost effectiveness of split ACs



The LCC of the units in each of the countries need a shift into this region for the total cost effectiveness of the unit

Cross-country comparison: EER vs Electricity Price

Electricity prices differ widely across countries



Source: GIZ Proklima 2018

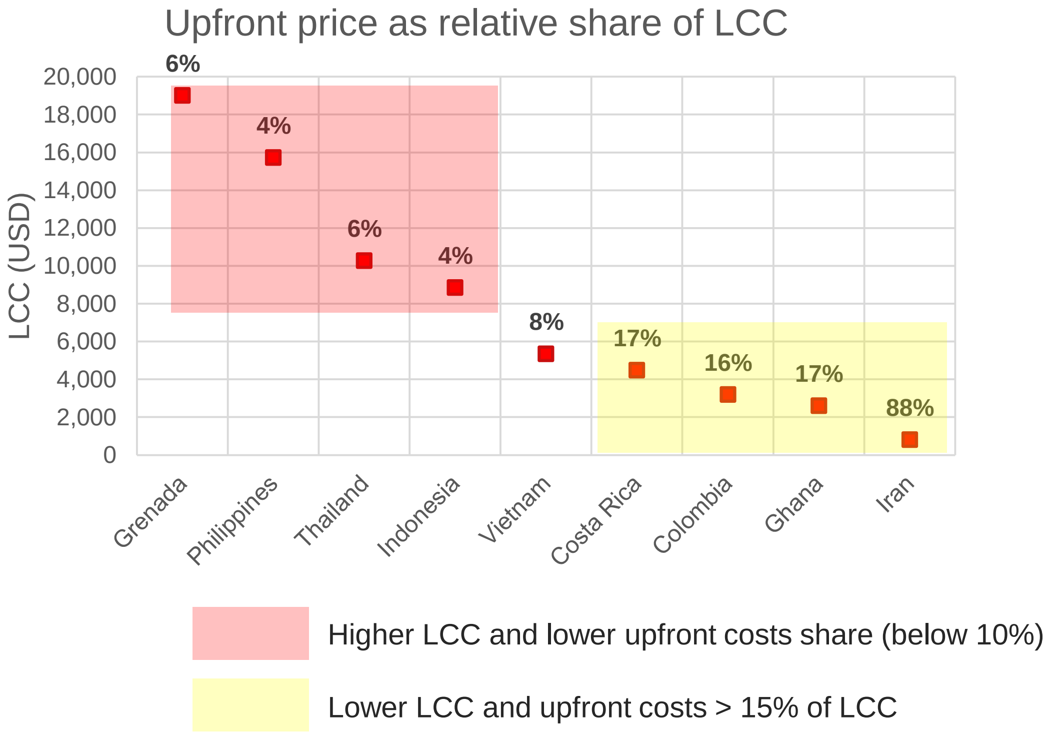
"Limited competition"

Cross-country comparison: LCC vs. Unit Price

LCC differ widely across countries

- **"Too cheap":** Appliances unit costs lower than 10% of LCC → appliances with better EER will have strong impact on lowering LCC: Grenada, Philippines, Thailand and Indonesia

- **"Price matters":** Countries with lower LCC and unit price over 15% of LCC: Markets more sensitive to higher appliance prices → Costa Rica, Colombia, Ghana and Iran



Source: GIZ Proklima 2018

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Unit pricing across countries

A sample brand was chosen with the same appliance cooling capacity and brand presence in most countries (not necessarily the same model, same EER);

Conclusions:

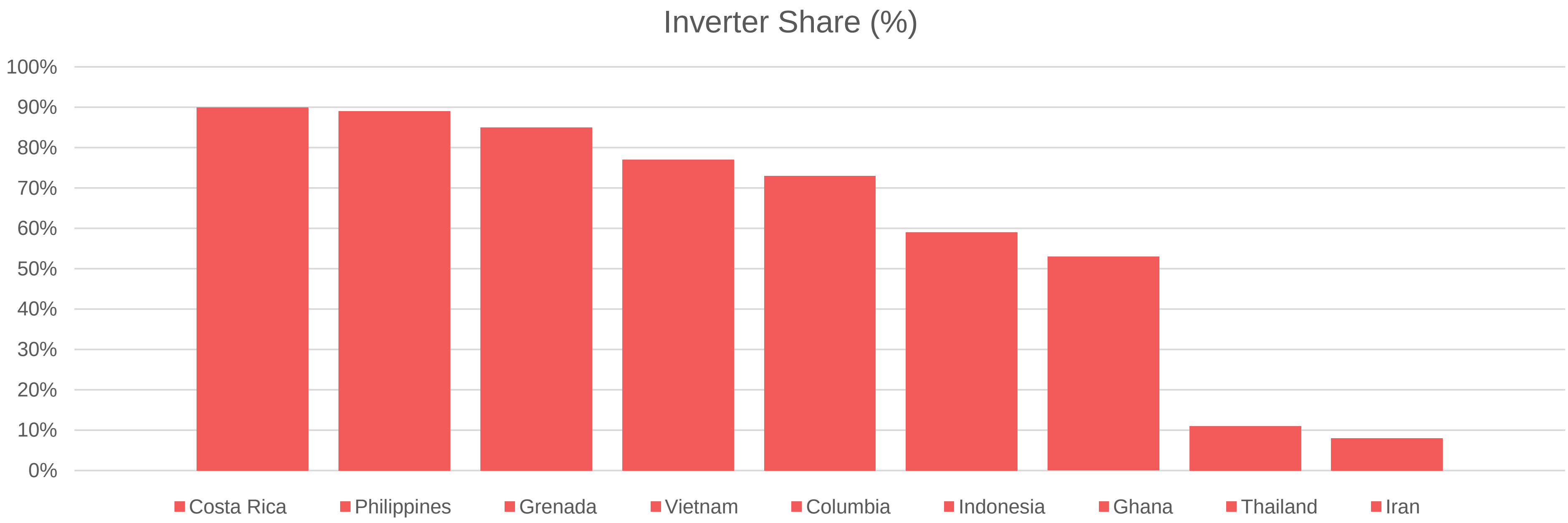
- For the same brand and capacity there is a wide price range among the countries with price difference of more than 100% (from 395 to 951 USD)
- Competition in the market seems to be the key price driver, while **costs for energy-efficient technologies** seem to have little influence on prices (market with highest EER, has lowest unit price)
- Feedback from countries shows that other factors are more influential than energy efficiency such as brand reputation, design, noise level

	EER	Unit price
Indonesia	**4.24**	**395**
Colombia	3.46	773
Vietnam	3.41	449
Philippines	3.41	751
Iran	**3.32**	**939**
Costa Rica	3.26	951
Ghana	3.00	665

Source: GIZ Proklima 2018

Inverter share per country

The share of inverter technologies (DC and AC VSD) compared to fixed non-inverter type between the displayed units was analyzed.



** Analysis based on the available data*

Source: GIZ Proklima 2018

Thank you for your attention!

Join our Webinar on detailed results of split AC analysis on **27 June 10 AM CET,** registration soon on our website at:

www.green-cooling-initiative.org

Have a look at our GIZ Proklima projects and publications at:

https://www.giz.de/expertise/html/4809.html

Further information:

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ANNEX 1: LCC calculation

- The cost analysis is done based on the **LCC method**

$$LCC = Initial\ Costs(IC) + Operating\ Costs\ (OC)$$

- Estimation of **operating cost (OC)**
  - Lifetime : 8 years (based on average lifetime modelled for developing countries)
  - Runtime: Based on Green Cooling Initiative RAC database
  - Emission factor: based on the IGES data and data from countries
  - Electricity prices from energy authorities
  - **LCC calculation**

$$LCC = IC + (\frac{OC}{(1+discount)^{lifetime}})$$

  - Discount rate: current discount rates from countries
  - Focus on cooling capacity class of 3-4 kW for comparative cross-country analysis

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ANNEX 2: Total Equivalent Warming Impact (TEWI)

- The emission scenario is modelled with TEWI
- Emissions from the energy consumption of the unit and the refrigerant leakage is considered for the TEWI analysis
- **Direct emission** include annual refrigerant leaks of a system, end-of-life disposal leakage and operational leakage
- **Indirect emission** include emissions from electricity generation and material manufacturing emissions (which are not included as they are generally <1% of total emissions)

Source: Guideline for life cycle climate performance, 2015 (IIR)