# Launching a DTV Transmitter Network with modern Transmitter Design

## or how GREEN is DVB-T2 with the latest transmitter technology

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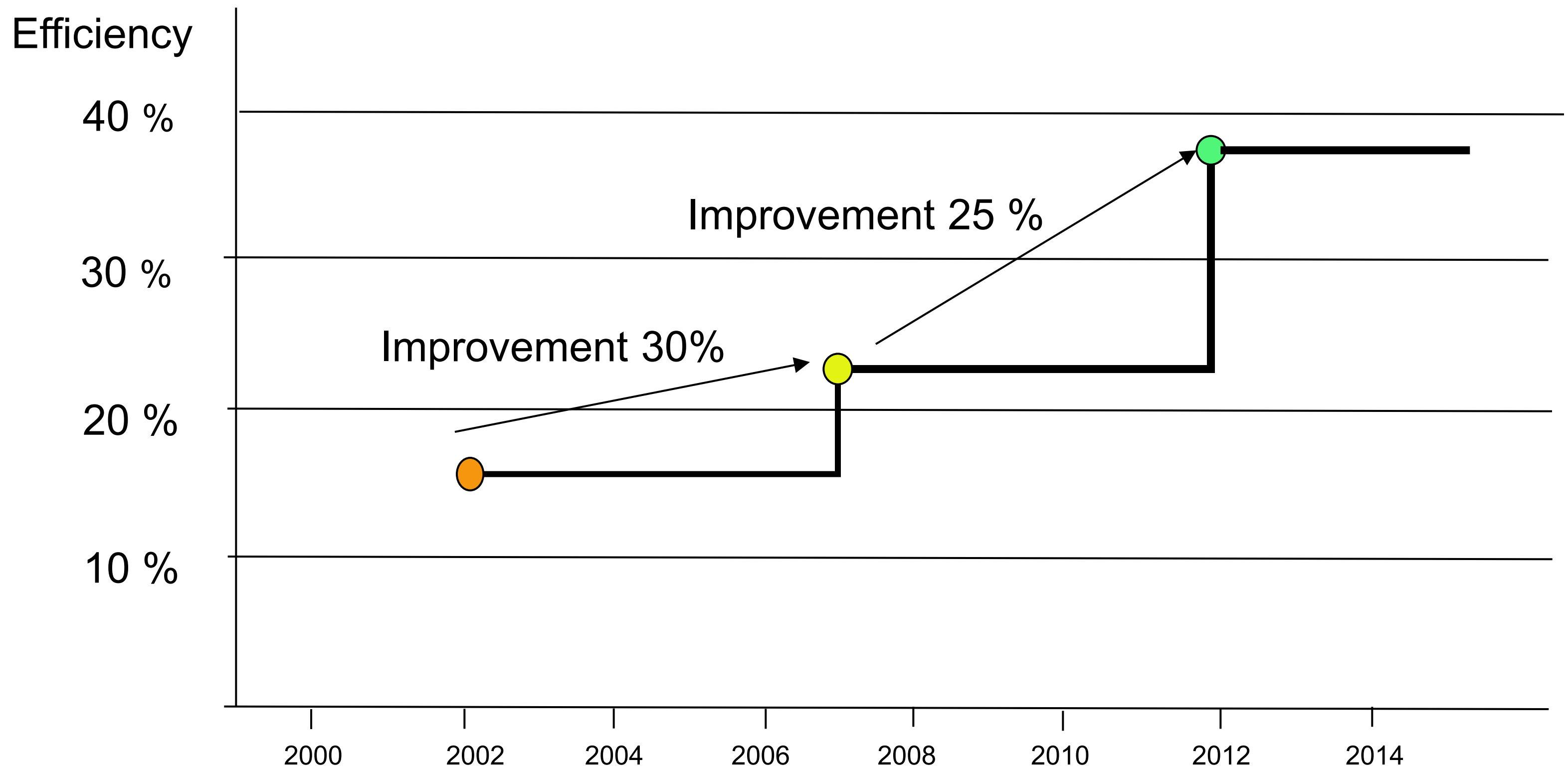
ROHDE&SCHWARZ

# Table of contents

# Digital UHF Market Leading Transmitter Generations…

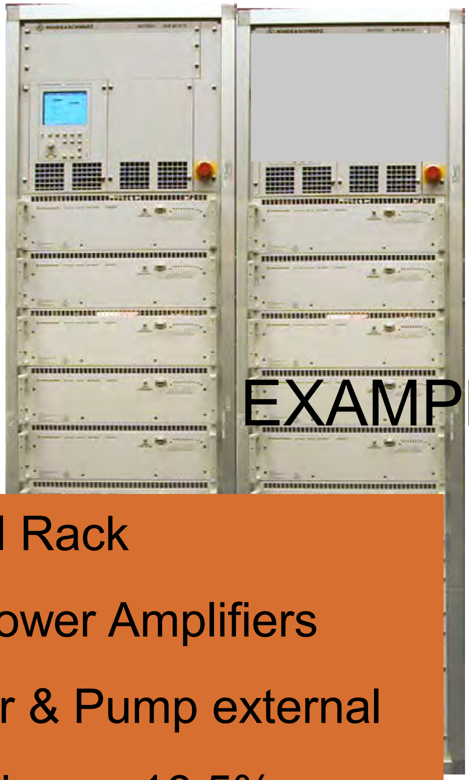



| | | | |
|---|---|---|---|
| **Max Output Power in 1 Rack** | **3,4 kW** | **6,1 kW** | **15 kW** |
| **Efficiency incl. Cooling** | **17%** | **22%** | **38%** |

# …and the impact for Digital TV Networks

**2002**

5 kW DVB-T



- Dual Rack
- 12 Power Amplifiers
- Filter & Pump external
- Efficiency: 16,5%

**2007**

5 kW DVB-T/T2

- Single Rack
- 8 Power Amplifiers
- Filter & Pump external
- Efficiency: 22 %

**2012**

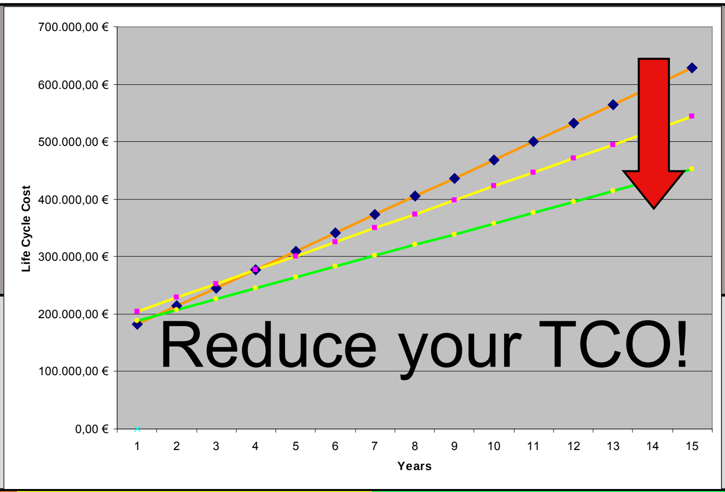
5 kW DVB-T/T2

- Single Rack
- 4 Power Amplifiers
- Filter & Pump internal
- Efficiency: 38 %

EXAMPLE: 5 kW DVB-T/T2 Transmitter

# Energy Efficiency & Operational Costs

| | Tx1 |
|---|---|
| Output Power DVB-T / T2 [kW] | **5,0** |




| | | | |
|---|---|---|---|
| Efficiency | 17% | 22% | 28% |
| Operational Costs per year (E... for the next years: 0.20 $ / kWh) | 53.090,37 $ | 40.368,67 $ | 31.285,72 $ |

**Savings per Year:**

≈ 22.000 $ (Tx3 vs Tx1)

≈ 9.000 $ (Tx3 vs Tx2)

Operational Costs for a Transmitter will go far beyond the Buying cost. **High Efficiency** is a Key Performance Indicator of a good Transmitter System

# System Compare & Improvements

| | DVB-T |
|---|---|
| Modulation | 16 QAM |
| FFT Size | 8k |
| Code Rate | 2/3 |
| Guard Interval | ¼ |
| Carrier Mode | Normal |
| Capacity | 13.3 Mbit/s |
| No. of Programs (MPE[illegible]) | 6 SD [illegible] HD |
| $E_{min}$ (500MHz, 1.5m) | 68,4 dBµV/m |

Same Coverage –

**Improved Payload Capacity**

Same Payload –

**Significant Coverage Improvement**

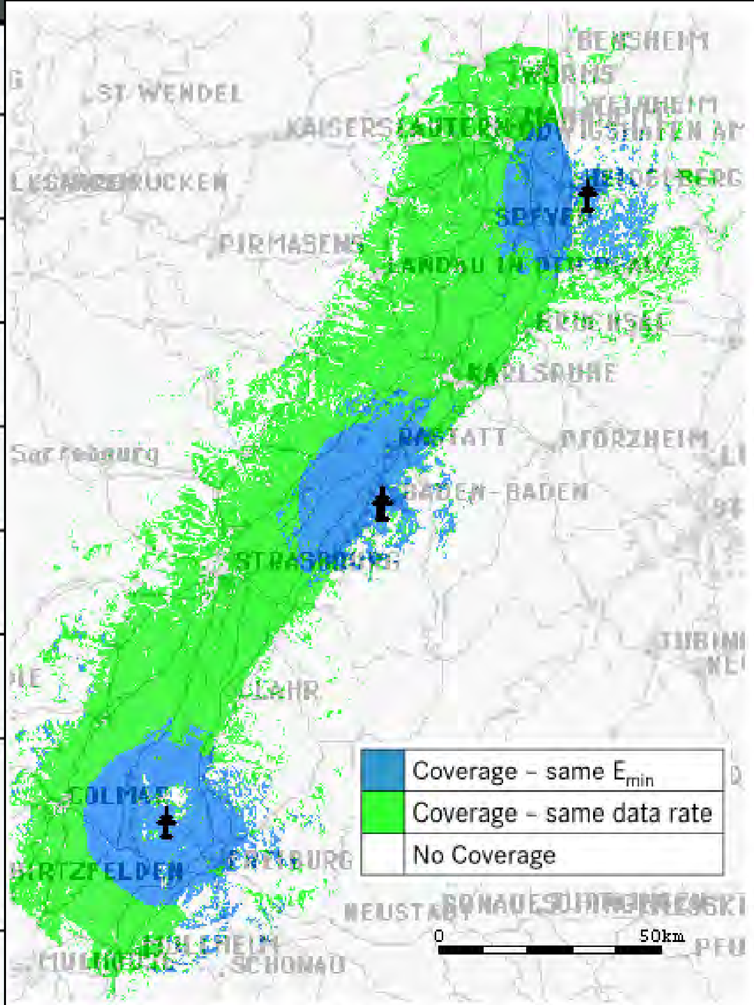



Figure 13: Coverage portable indoor reception for same $E_{min}$ and same data rate

# System Compare & Improvements

| | DVB-T | DVB-T2 | DVB-T2 |
|---|---|---|---|
| Modulation | 16 QAM | 64 QAM | 16 QAM |
| FFT Size | 8k | 16k | 16k |
| Code Rate | 2/3 | 2/3 | 3/5 |
| Guard Interval | ¼ | 1/8 | 1/8 |
| Carrier Mode | Normal | Extended | Extended |
| Capacity | 13.3 Mbit/s | 25.0 Mbit/s | 15.0 Mbit/s |
| No. of Programs (MPEG4) | 6 SD<br>1 HD | [illegible] SD<br>2 HD | 6 SD<br>1 HD |
| [illegible] min (500MHz, h.5m) | [illegible] dBµV/m | 68,6 [illegible] | [illegible] dBµV/m |

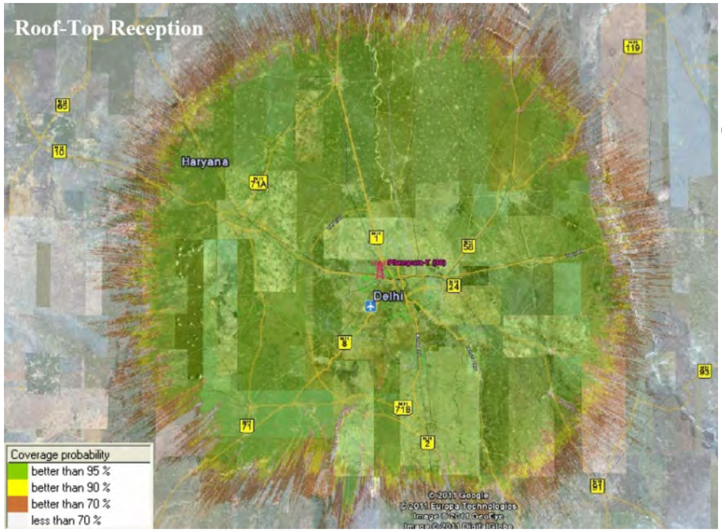
DVB-T2 can give 50% ++ increase in payload capacity at the same C/N ratio

DVB-T2 can deliver the same payload and cover the same area with 5 dB – 7 dB weaker signals

**Effective Spectrum saving 50% (Approx)**

**Reduction of Transmitter Output power to ¼**

# System Compare & Improvements




ERP 30kW

DVB-T Coverage

64QAM, CR 2/3,
Guardinterval ¼,

**Bitrate 19,9MBit/s**

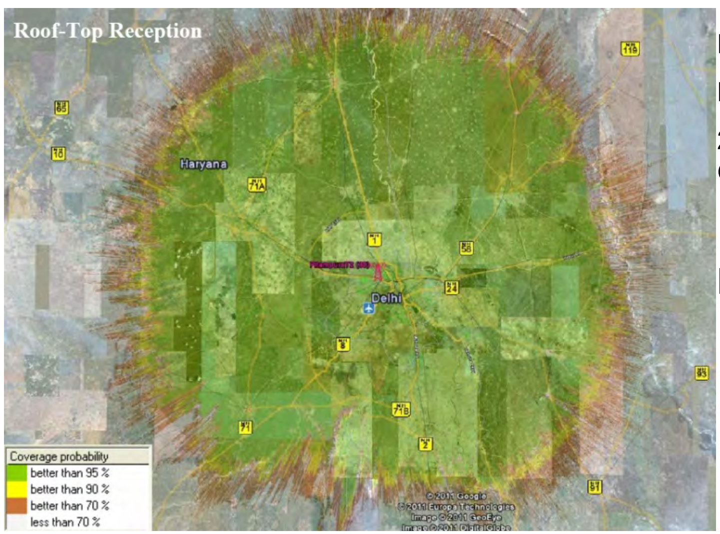
Same Coverage area, but significantly Payload increase

DVB-T Coverage

System:
64 QAM, 8k, CR ¾
Guard interval 1/8

**24,8 Mbit/s**
**C/N 18,6 dB**

Same Payload and improved coverage area, but significantly improved C/N




ERP 30kW

DVB-T2 Coverage

256QAM, CR 3/5, 32k Ext,
Guardinterval 1/128

**Bitrate 36,1 MBit/s**

DVB-T2 Coverage

System:
16 QAM, 32k etx.
CR 5/6
Guard interval 1/32

**23,8 Mbit/s**
**C/N 13,4 dB**

Coverage probability
better than 95 %
better than 90 %
better than 70 %
less than 70 %

# Comparision DVB-T vs DVB-T2

## Coverage – Tx Output Power – Data Rate

| Scenario | Tx Output Power | Data Rate | Coverage | Remarks |
|---|---|---|---|---|
| 1 | = | = | ↗ | Keeping the Modulation |
| 2 | = | ↗ | = | Using a higher Modulation |
| 3 | ↘ | = | = | Keep Modulation and use PAPR |
| 4 | ~~↘~~ | ~~↗~~ | ~~↗~~ | Not Valid |

1) Make your Network planning first
2) Set up your Priorities ( More Programs or HD Services, better coverage , etc)
3) Check your requirements ( SFN, IP distribution, SPLP or flexible MPLP )

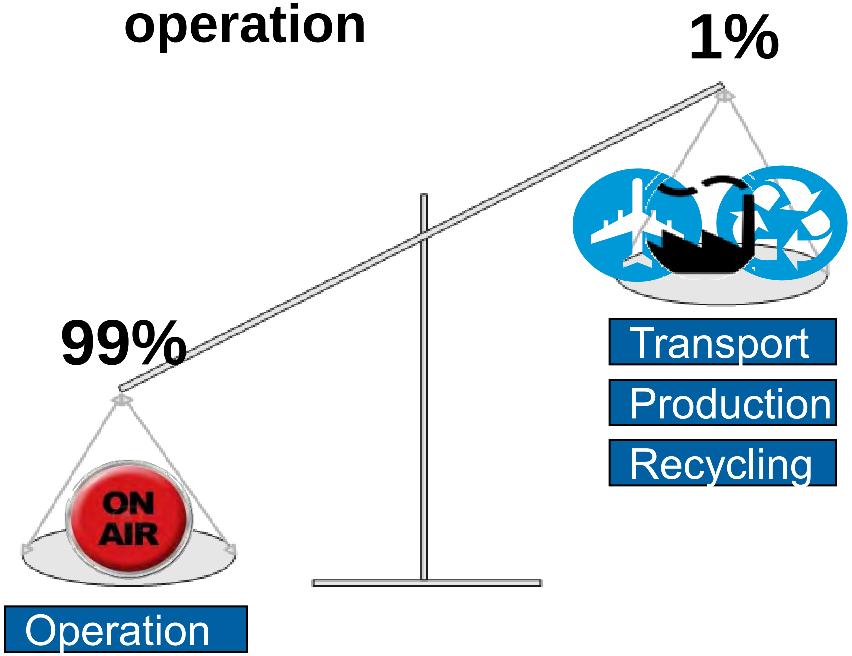
# Energy Efficiency

# Reducing Costs

# Space Efficiency

# Energy Efficiency

- 99% of the energy for a broadcasting Tx is required during operation




- 99% of the carbon footprint generated during operation

➔ **Reducing the energy requirement during operation best approach to reduce carbon footprint**

➔ **Power efficiency of a transmitter reflects its carbon footprint**

# Focus on transmitters
## How to calculate power efficiency

Energy
Input
incl. cooling at a specific signal quality level

Useful RF Energy
Tx Output

Energy dissipated

to the room (heat)

to the outside (heat)

| |
|---|
| **Modulation Error Rate (MER): 33dB** |
| **Shoulder Setting: 37dB** |

$$Power\ Efficiency = \frac{Useful\ Energy\ Output}{Total\ Energy\ Input}$$

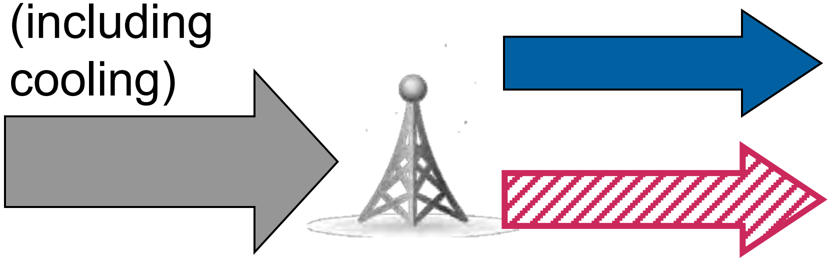
# Example
## 1 kW digital TV Transmitter

5 kW

Energy input (including cooling)

RF energy output

1 kW



4.00 kW

Energy dissipated to ambience (heat)

- **Assuming 20% efficiency**
  **➔ *1kW / 20% = 5.00 kW***
- **5 kW x 24 h x 365 days**
  **➔ 43,800 kWh**
- **43,800 kWh x 1.5 pounds per kWh**

**➔ 33 tons of $CO_2$ produced per year**

- **Typical conversion formula from electrical energy consumption to carbon emission:**
  1 kWh = 1.5 pound $CO_2$ (coal-fired power plant), source: Michael Bloch, www.carbonify.com

# Energy Efficiency I
## How to reduce Energy costs

- **Highest Factor in Transmission costs is Energy costs**

- **Reducing Energy costs by using modern & highly efficient Transmitter technologies such as**

***Doherty & Crest Factor Reduction***

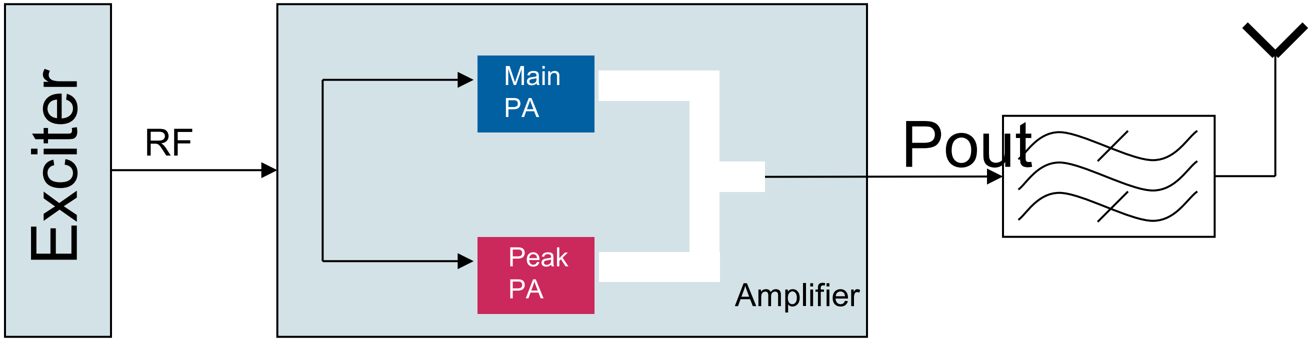
- **Improving Efficiency for Digital Broadcast Transmitter from 20% to**

**38% (UHF)**

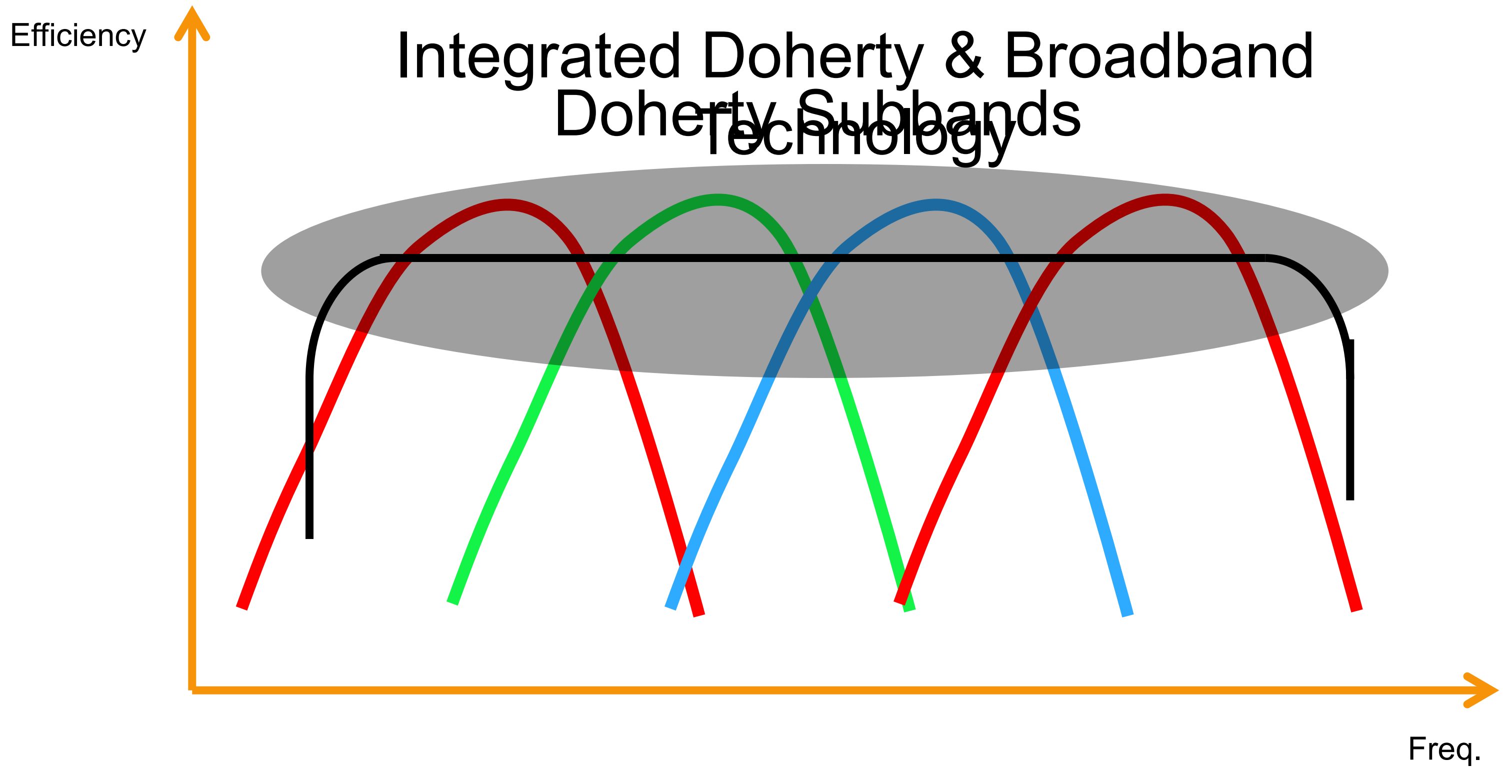
**46% (VHF)**

# Efficiency enhancement technologies
## Doherty amplifier

- **Amplification for main and peak signals is separated**
  - Main amplifier amplifies average signals (class A/B)
  - Peak amplifier amplifies peak signals (class C)
  - ➔ lower headroom in main amplifier required
  - ➔ No energy required in peak amplifier as long no peaks are in the signal



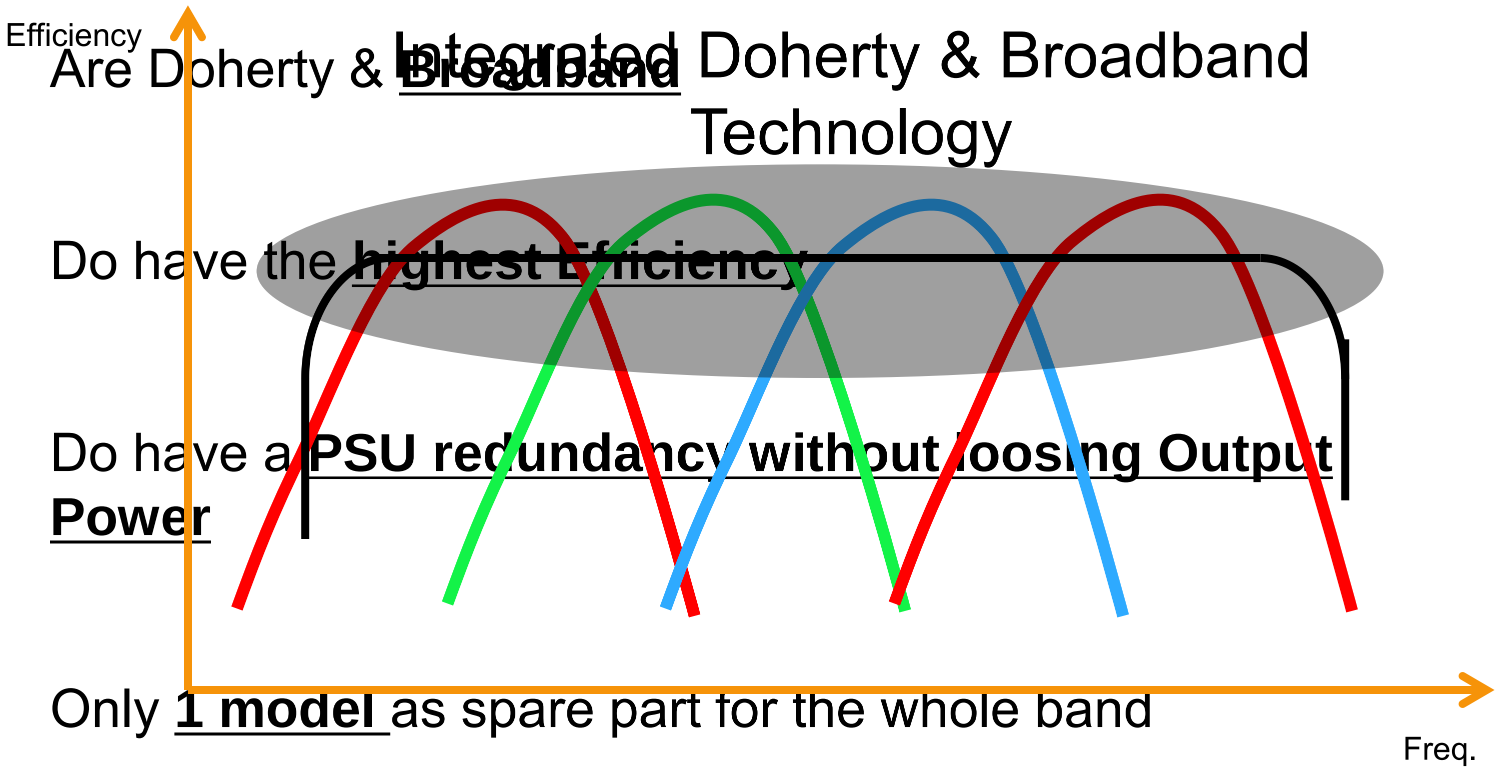
# The High Efficiency Doherty Power amplifier



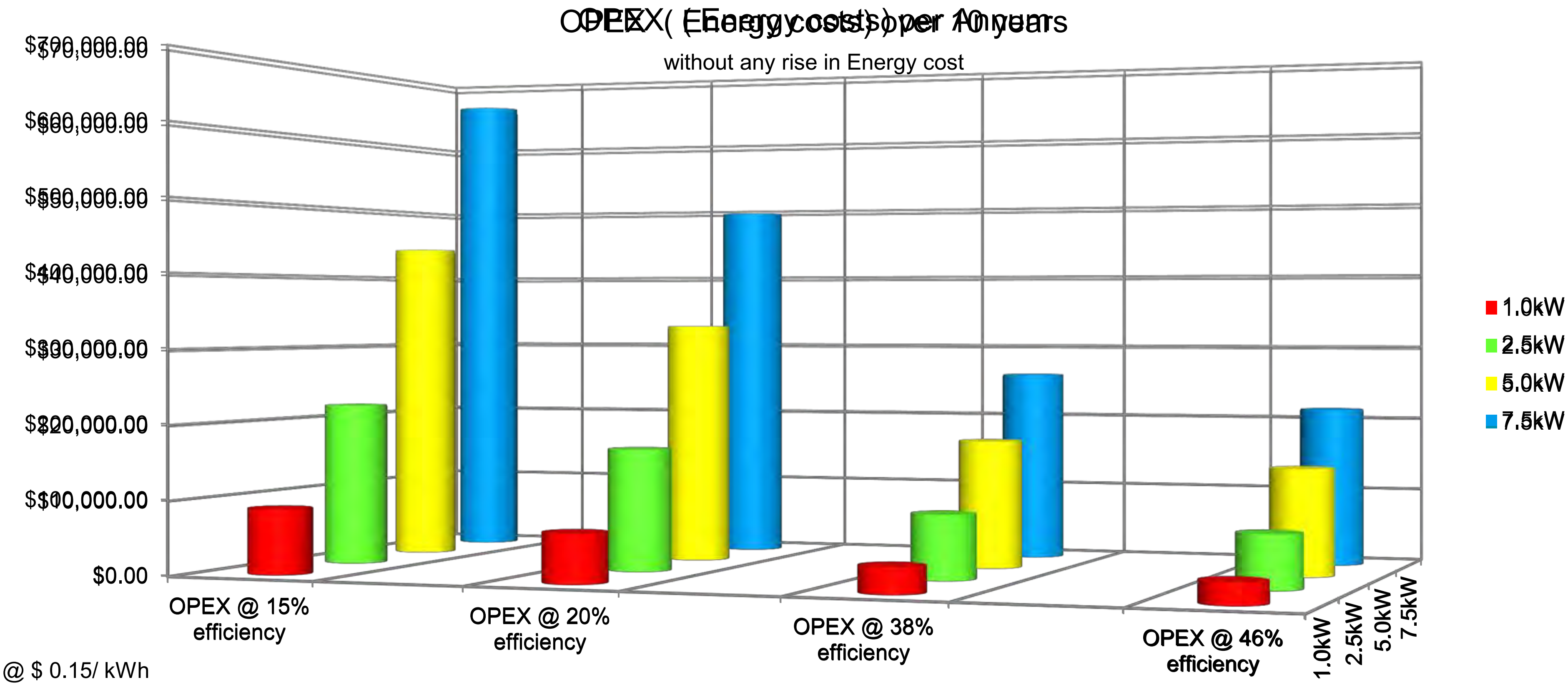
# The High Efficiency Doherty Power amplifier

Rohde & Schwarz Doherty Power Amplifier:

- Are Doherty & **Broadband**
- Do have the **highest Efficiency**
- Do have a **PSU redundancy without loosing Output Power**
- Only **1 model** as spare part for the whole band



| | Output Power [kW] | 1.00 | 2.50 | 5.00 | 7.50 |
|---|---|---|---|---|---|
| | OPEX @ 15% efficiency | $87,600 | $219,000 | $438,000 | $657,000 |
| | OPEX @ 20% efficiency | $65,700 | $164,250 | $328,500 | $492,750 |
| UHF Tx | OPEX @ 38% efficiency | $34,579 | $86,447 | $172,895 | $259,342 |
| VHF Tx | OPEX @ 46% efficiency | $28,565 | $71,413 | $142,826 | $214,239 |

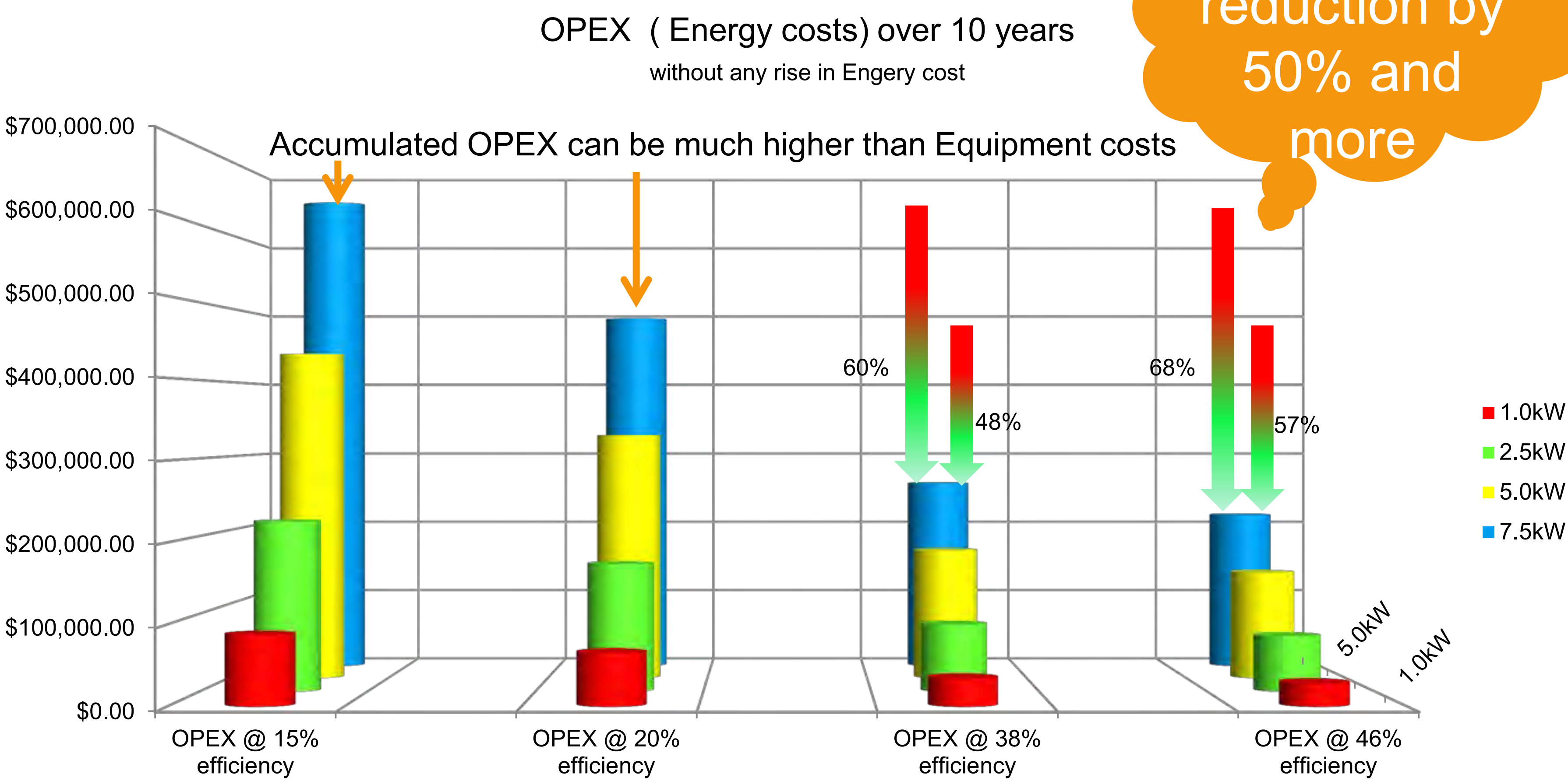



@ $ 0.15/ kWh

# Costs

## Significant Reduction in Energy costs

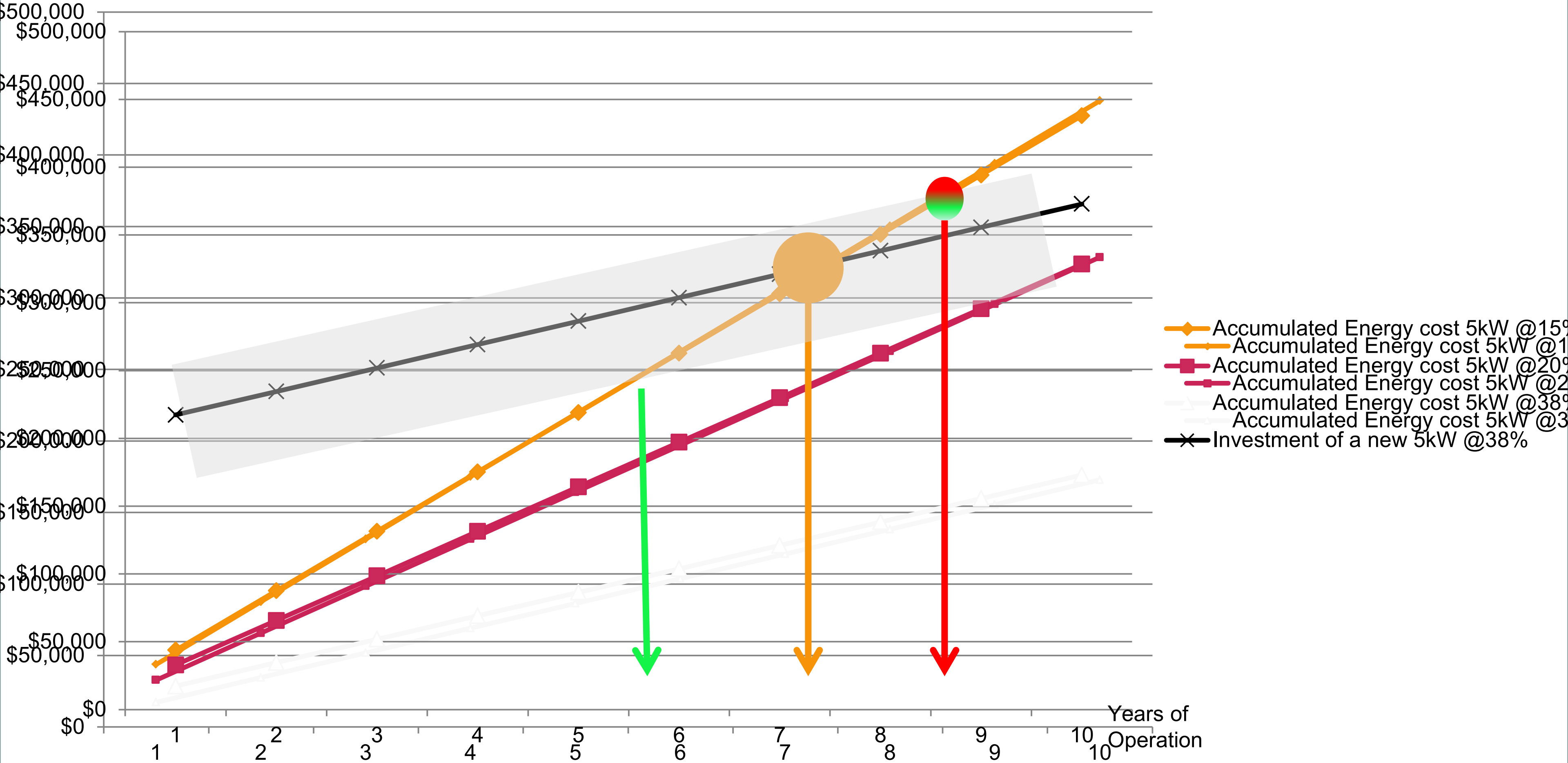
Energy Cost reduction by 50% and more




@ $0.15 /kWh

# Costs…some thoughts

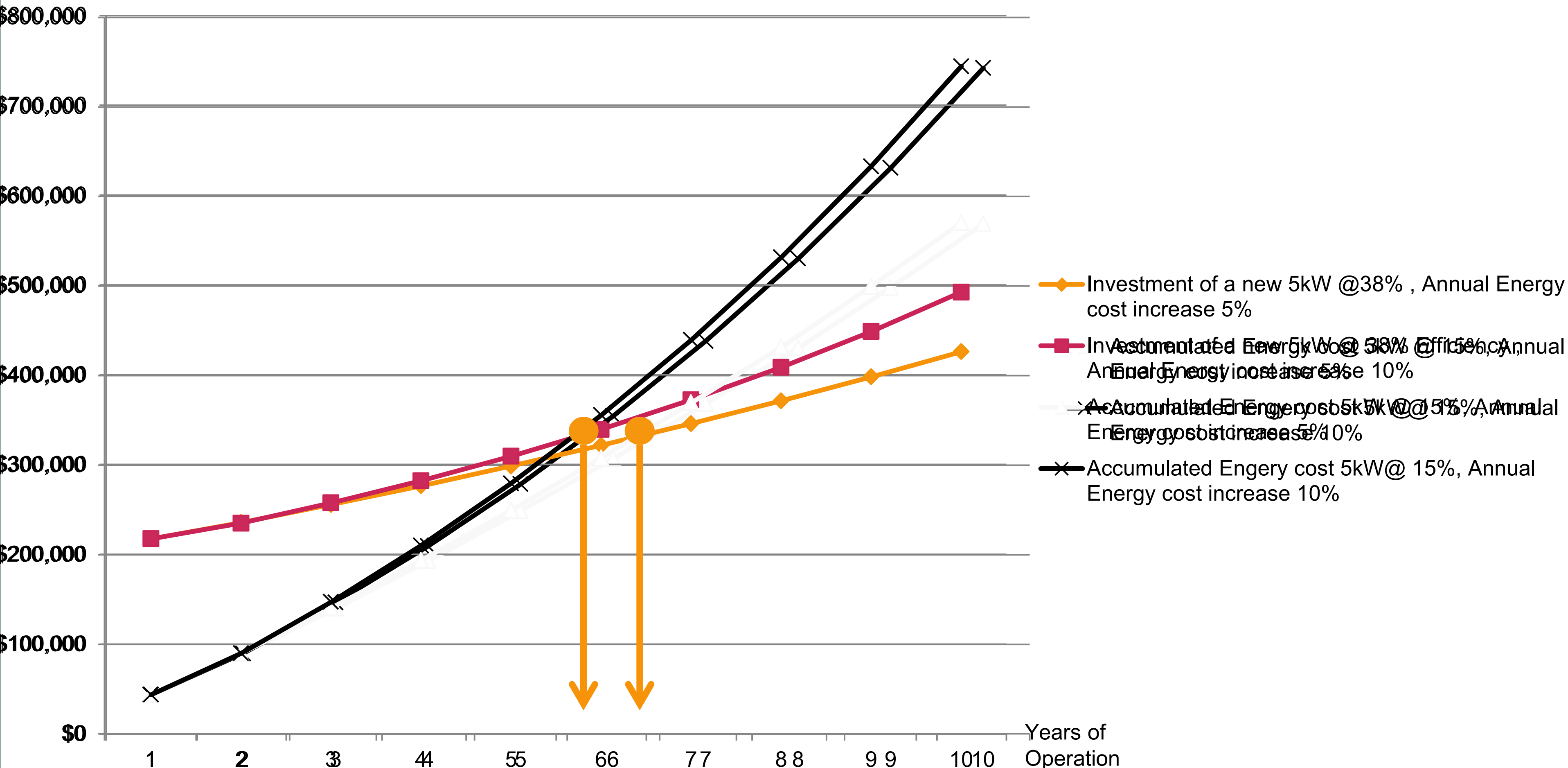
## When is the right moment for new investments…Example 1




@ $ 0.15/ kWh

# Costs…some thoughts

## When is the right moment for new investments…Example 2

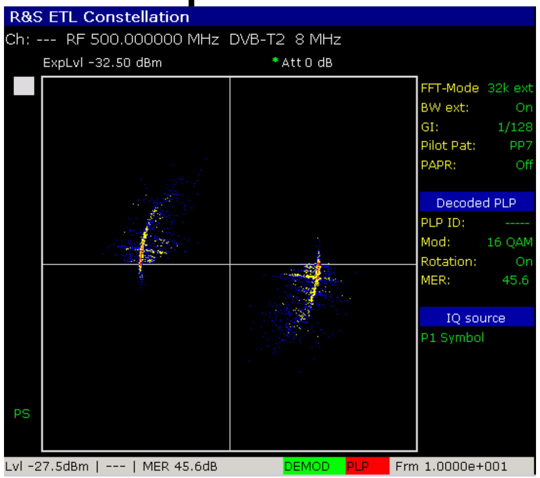



Year 1 @ $ 0.15/ kWh

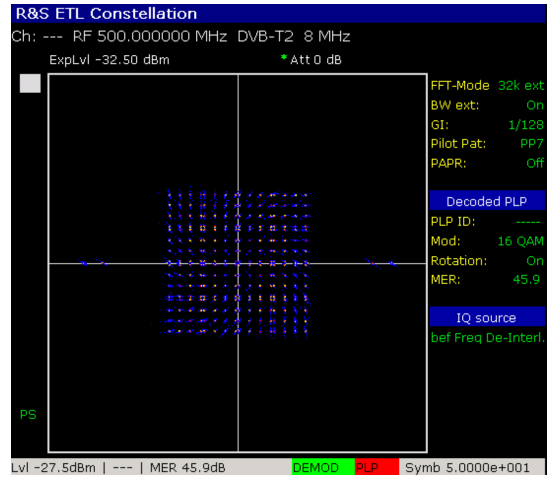
# DVB-T2 Measurements I

- **DVB-T2 Measurements are more complex than DVB-T**

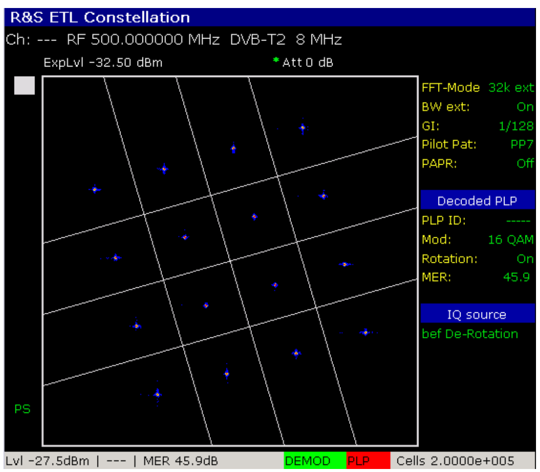
Examples



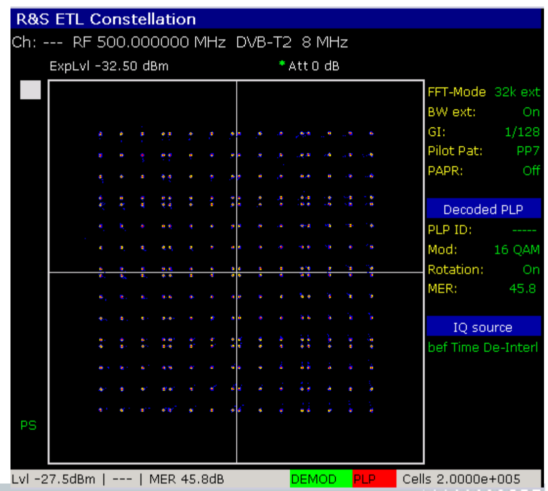

P1 Symbol




OFDM Cells before Frequency De-Interleaving




PLP Cells before De-Rotation

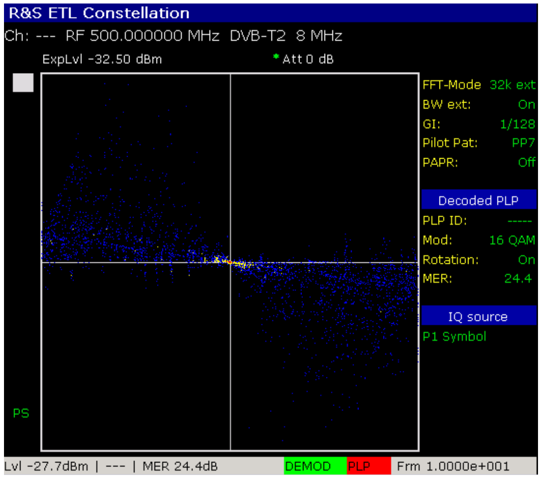



PLP Cells before Time Interleaving

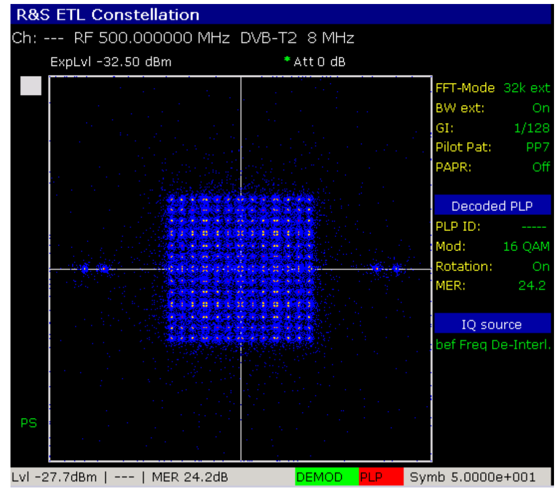
# DVB-T2 Measurements II

- **DVB-T2 Measurements are more complex than DVB-T**

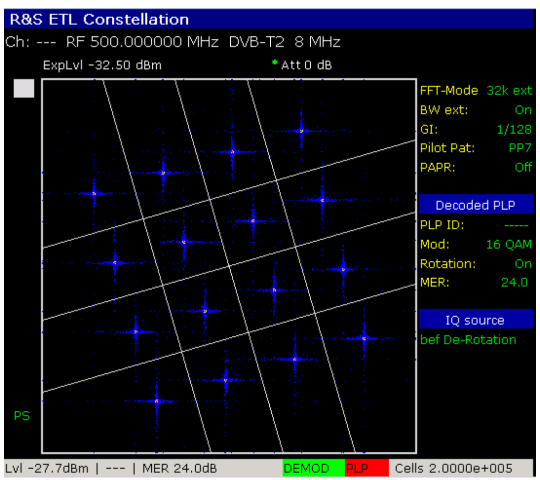
Examples: **BUT WHO CAN TELL WHICH ONE IS GOOD, ACCTEPTABLE OR BAD**



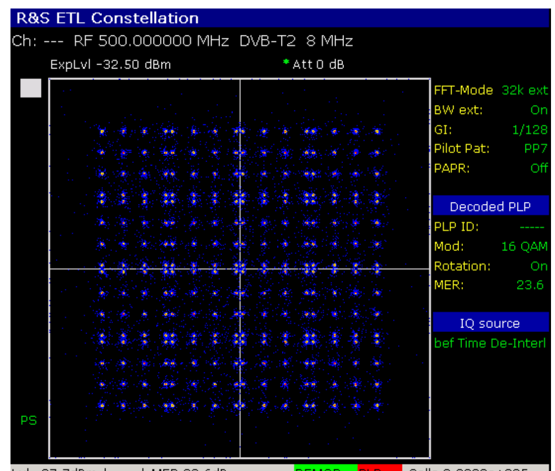

P1 Symbol




OFDM Cells before Frequency De-Interleaving




PLP Cells before De-Rotation




PLP Cells before Time Interleaving

# DVB-T2 Configurations

8MHz Channel, 32K FFT, 1/128GI, PP7

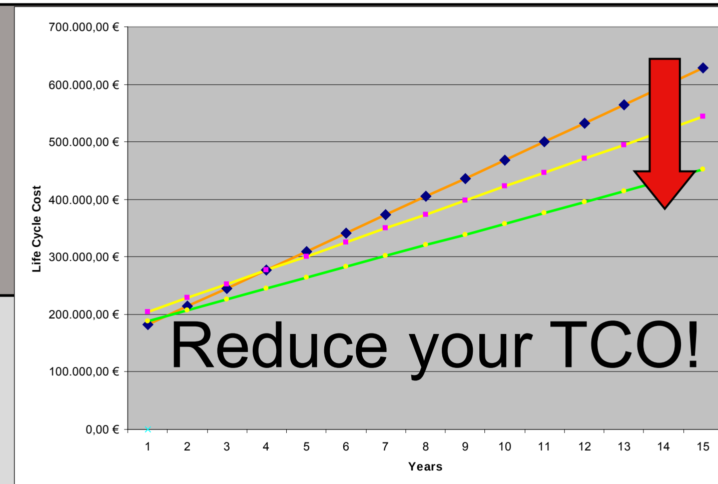
| Modulation | Code rate | Absolute maximum bit-rate | | | Recommended configuration | | |
|---|---|---|---|---|---|---|---|
| | | Bitrate Mbit/s | Frame length $L_F$ | FEC blocks per frame | Bitrate Mbit/s | Frame length $L_F$ | FEC blocks per frame |
| QPSK | 1/2 | 7.49255 | 62 | 52 | 7.4442731 | 60 | 50 |
| | 3/5 | 9.003747 | | | 8.9457325 | | |
| | 2/3 | 10.01867 | | | 9.9541201 | | |
| | 3/4 | 11.27054 | | | 11.197922 | | |
| | 4/5 | 12.02614 | | | 11.948651 | | |
| | 5/6 | 12.53733 | | | 12.456553 | | |
| 16-QAM | 1/2 | 15.03743 | 60 | 101 | 15.037432 | 60 | 101 |
| | 3/5 | 18.07038 | | | 18.07038 | | |
| | 2/3 | 20.10732 | | | 20.107323 | | |
| | 3/4 | 22.6198 | | | 22.619802 | | |
| | 4/5 | 24.13628 | | | 24.136276 | | |
| | 5/6 | 25.16224 | | | 25.162236 | | |
| 64-QAM | 1/2 | 22.51994 | 46 | 116 | 22.481705 | 60 | 151 |
| | 3/5 | 27.06206 | | | 27.016112 | | |
| | 2/3 | 30.11257 | | | 30.061443 | | |
| | 3/4 | 33.87524 | | | 33.817724 | | |
| | 4/5 | 36.1463 | | | 36.084927 | | |
| | 5/6 | 37.68277 | | | 37.618789 | | |
| 256-QAM | 1/2 | 30.08728 | 68 | 229 | 30.074863 | 60 | 202 |
| | 3/5 | 36.15568 | | | 36.140759 | | |
| | 2/3 | 40.23124 | | | 40.214645 | | |
| | 3/4 | 45.25828 | | | 45.239604 | | |
| | 4/5 | 48.29248 | | | 48.272552 | | |
| | 5/6 | 50.34524 | | | 50.324472 | | |

Good coverage for 3 HDTV programs (MPEG4)

High Bitrate for 6 HDTV programs (MPEG4)

# Space Efficiency & Operational Costs

| | Tx1 | | |
|---|---|---|---|
| Output Power DVB-T / T2 [kW] | 3 x 5,0 | | |
| Floor space needed (w/o cooling infrastructure) | min 6 racks (~4 m²)) | min. 3 racks (~2 m²) | only 1 rack (≤1 m²) |
| Floor space costs per year (assuming 1000$ per m²) | ~ 4.000 $ | ~ 2.000 $ | < 1.000 $ |




**Savings per Year:**

≈ 3.000 $ (Tx3 vs Tx1)

≈ 1.000 $ (Tx3 vs Tx2)

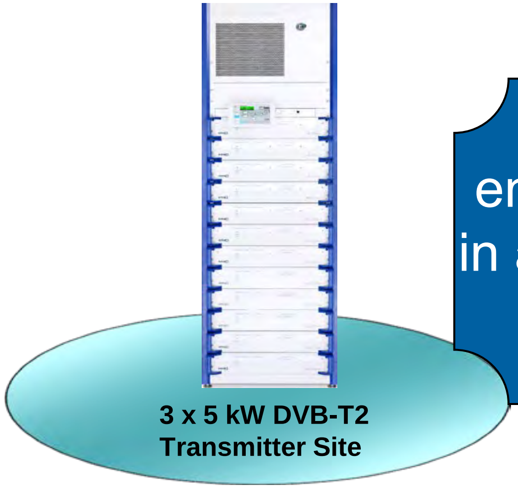
Operational Costs for a Transmitter will go far beyond the Buying cost. **Space Efficiency** is one Performance Indicator of a good Transmitter System

# E$^5$ - Efficiency to the Power of Five
## Effects for a DVB-T2 network deployment

- Outstanding energy **E**fficiency:
  cost savings over the system lifetime
- Space **E**fficiency:
  smaller footprint yet more power
- Operational **E**fficiency:
  faster operation and more functionality
- **E**fficiency for customer requests:
  customized system solutions
- Investment **E**fficiency:
  modular system concept for future needs

**Over 40% energy savings compared to 7th Tx generation**

(with an efficiency gain of up to 70%)




**Possible energy saving in a T2 network:**

**$\geq$ 85%**

(significant reduction of operation costs)

**Energy savings of up to 75% switching from DVB-T to -T2**

# Thank you!