POWER PRICE FORECASTING SUMMIT 2022
#PowerPrice2022

Risk management of Renewable Assets

Stochastics and Fundamentals

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KYOS Energy Analytics

Thu 9 June 2022

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Agenda

- Introduction
- Risk management of renewable energy assets
- Price and Capture rate forecasting using a fundamental approach
- Joint processes for renewable power generation and power prices
- Profit-at-Risk for a PPA with hedges
- Evaluating dynamic hedging (stack and roll)

Introduction KYOS

Background

- Activities started in 2002; KYOS founded in 2008
- Specialist in energy & commodity markets: trading, valuation, risk management
- Core competence: combine quantitative background with practical solutions
- Experienced and dedicated expert team

Activities

- Modelling

  Apply quantitative financial engineering to energy markets

- Software

  Provide user-friendly software for daily use

- Advisory and Training

  Combine advanced models with practical insights

ISO 27001:2017 Certified by Brand Compliance

SILVER 2021 ecovadis Sustainability Rating

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Introduction KYOS

Who we are

- International client base across Europe, plus Americas and Japan
- 30+ people, of which 20+ in Haarlem
- More than 100 corporate clients for its software services
- International partners to serve our global client base

Risk management of renewable assets

Why is risk management important?

General trend:

Move to post-subsidy world

Stable/predictable income → exposure to market prices

Feed-in tariffs CfD mechanisms Price support mechanisms	PPAs Market prices Hedging

Requires more sophisticated tools to assess future cashflow development

And it is necessary!

Hundreds of market players are trying to develop new projects

- Traditional utilities and energy trading companies
- Oil and gas majors, diversifying to electricity
- Investment funds
- Many other new-comers in the merchant energy space

Northland Power
ERG
NEOEN
ENCAVIS
BORALEX
Solaria
INNERGEX
TERNA ENERGY
OX2

The focus has been on expansion, expansion, expansion

Portfolios are becoming larger and many players lack insight in the risks

This might lead to unexpected losses and hamper further investments

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Managing a portfolio

A portfolio of renewable production with hedges leads to complex (residual) risks

Examples of questions you want to get answered:

- What is my expected monthly cashflow?
- What is my 5% worst case monthly cashflow?
- What will my cashflows be in a year with 5% worst case production?
- How will my risk distribution change with additional hedges?
- How will my risk profile change when I add another asset to my portfolio?

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What tools do you need?

1. **Fundamental power market model.** Creates long-term hourly price forward curves, based on market scenarios. This forms the basis for all business case analysis, including price and capture rate forecasts.
2. **Monte Carlo price simulation engine.** Actual market price dynamics are more diverse than can fundamentally be modelled. Monte Carlo and other techniques can generate a more realistic variety of price and volume paths, which is key to valuation and risk management.
3. **PPA valuation and hedging tool.** Assesses the market value of a renewable generation asset or PPA. And calculates how the asset can be optimally hedged using market contracts.
4. **Portfolio risk engine.** Provides insight in a portfolio of assets and contracts, quantifying the exposures, mark-to-market, Value-at-Risk and Cashflow/Profit-at-Risk.

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Why use fundamental information?

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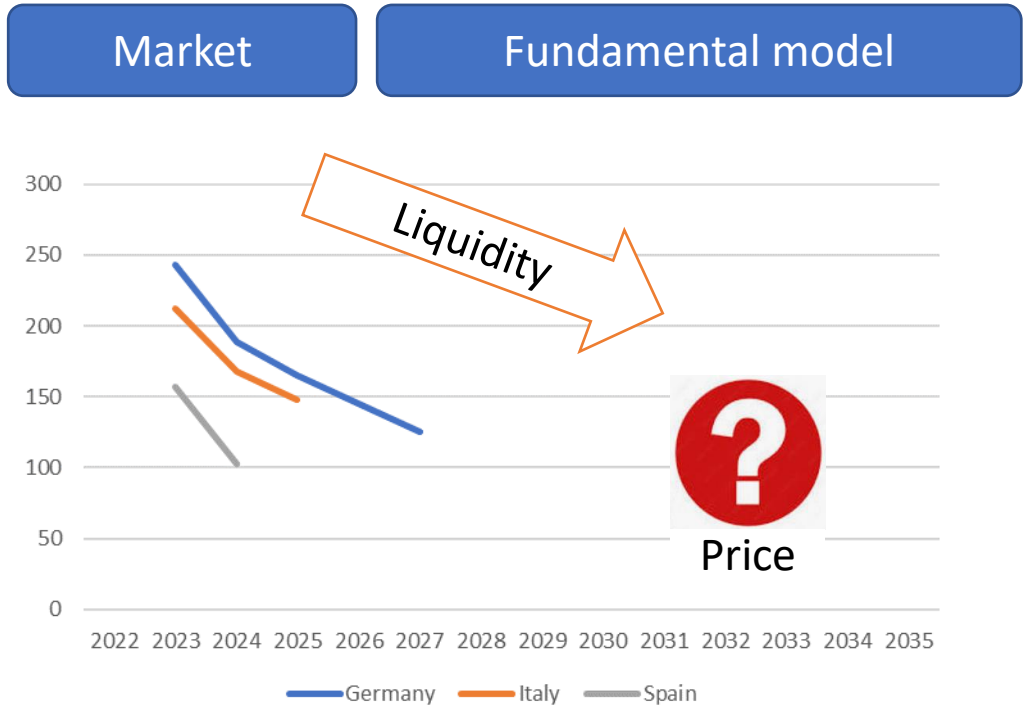
Why worry about power price in 2030? Or 2035?

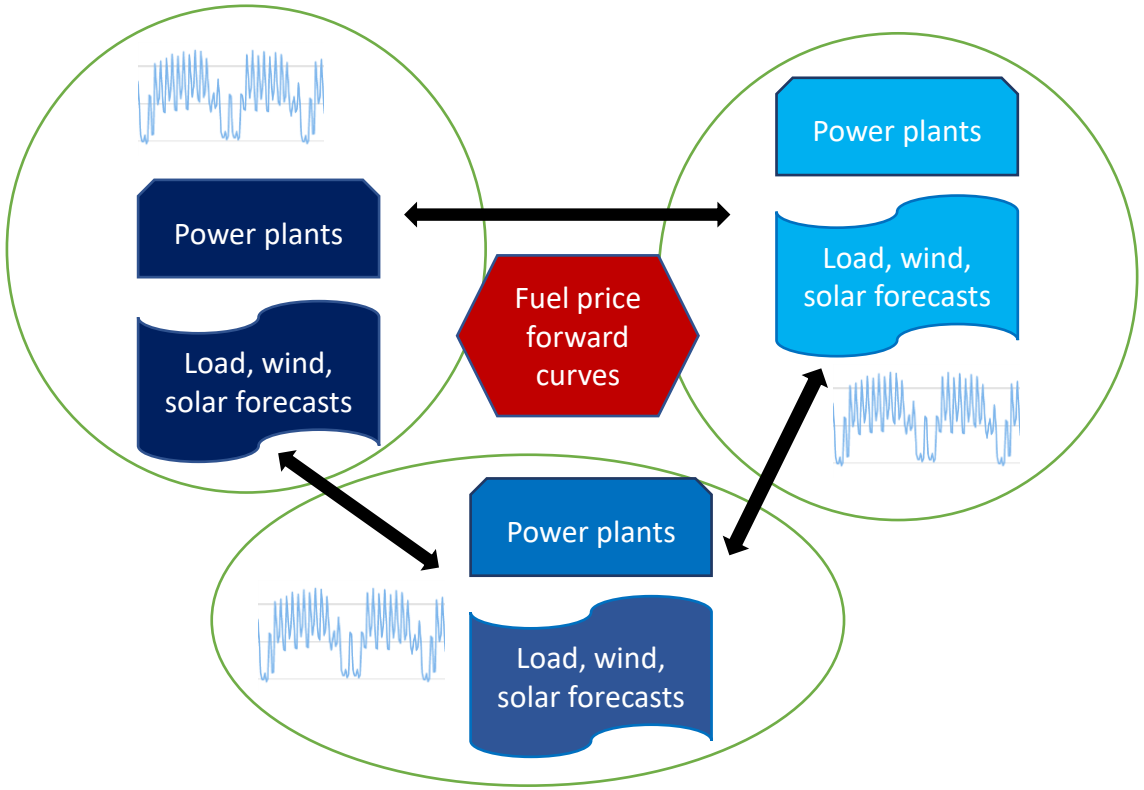
- Liquid power trading just a few years ahead
- Projects will not earn back investment in 3 years, nor in 5 years
- In the next 10-20 years, market will undergo transformation



Why run your own fundamental scenarios?

1

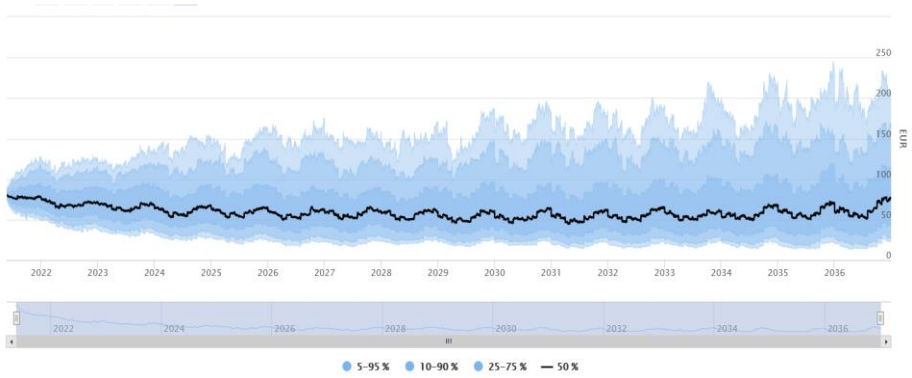
- There are many future unknowns
- With your own fundamental analysis, you can vary input assumptions
- And get more insight in risks, then when you rely on standard reports
- You can adapt directly to new regulations, new fuel price forecasts or new government policies
- You can assess the future capture rates of the market AND of individual projects



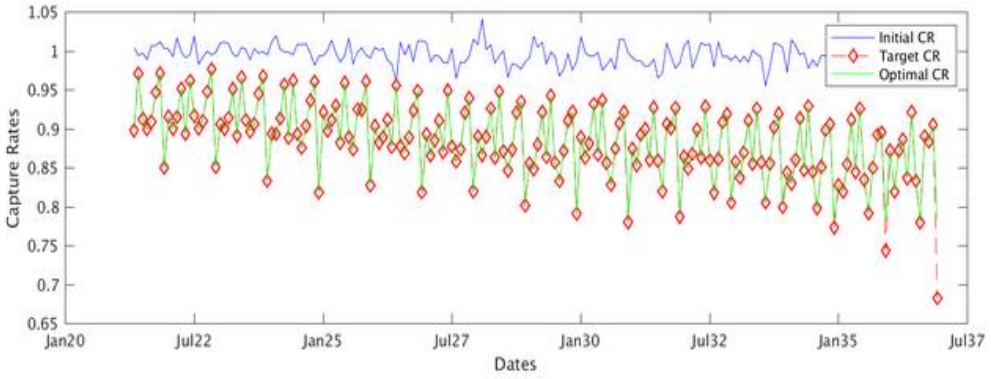
How to generate many simulations?

- Two decades of research and development are incorporated in our simulation engines
- The basis is the detailed simulation, with multi-factor modeling and Monte Carlo, of forward prices and spot prices
- This is combined with ‘smart sampling’ techniques to generate realistic scenarios of weather, renewable generation and balancing prices

Prices



Volumes and capture rates



How does the weather sampling work?

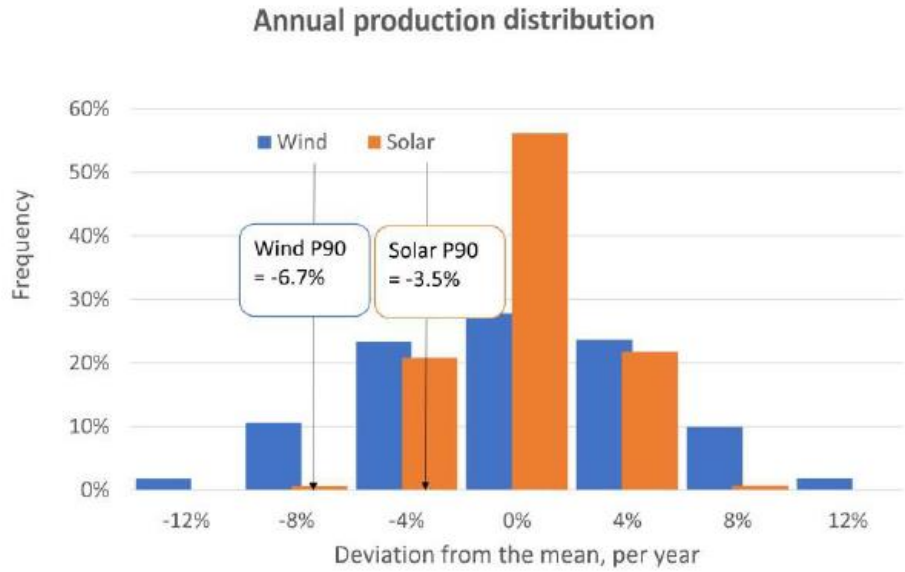
- Time-series modelling of (many correlated) weather, volume and price time series is virtually impossible.
- By sampling from historical weather data, we obtain realistic dynamics: correlations, standard deviations, etc.

We take advantage of these weather data characteristics when simulating weather time-series. The sampling methodology creates N future weather scenarios (e.g. with N = 1000), for future years F1 to F2 (e.g. from 2025 to 2035), using past weather data of the years P1 to P2 (e.g. from 2005 to 2016), by sampling in blocks of 2 weeks.

This means, for each scenario j:

- Randomly select a year P(j,1) from the past: P1 <= P(j,1) <= P2
- Take the first 2 weeks from that historical year to collect 2 x 7 x 24 = 288 hours of weather data. This is the scenario for the first 2 weeks in the future.
- Randomly select a new year P(j,2) from the past.
- Take the second 2-weekly period from that year P(j,2) to collect a new series of 288 hours of weather data. This is the scenario for the second 2 weeks in the future. Concatenate ("glue") this to the first 2 weeks.

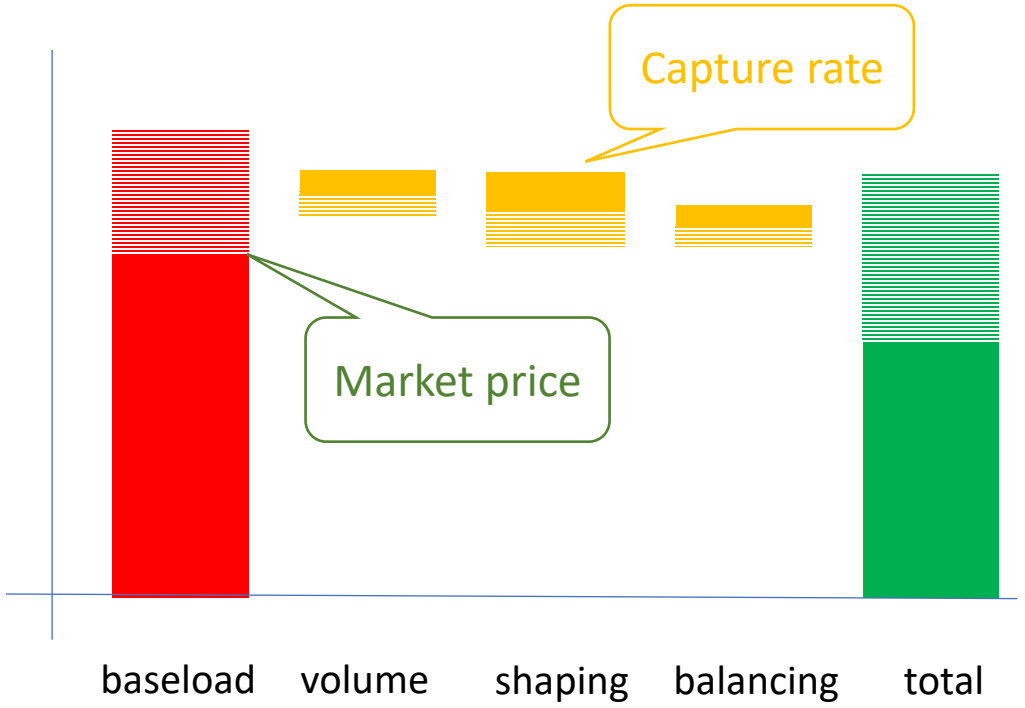
Repeat step 3 and 4 multiple times till the scenario reaches the end of the future horizon.



PPAs can be complex

PPA

- Complex, non-standard, contracts
- Typical examples:
  - Pay-as-produced, floating price (with cap/floor)
  - Pay-as-produced, fixed price
  - Baseload profile, fixed price
- Typical counter parties:
  - Utilities/traders
  - Corporates
- Pricing complex, requires advanced valuation tool



Each PPA may distribute the value components differently, but ultimately they have to land in someone's pocket.

Example analysis of caps and floors

Floating price, with various cap/floor levels

- With a floor and cap, the PPA cash-flows are more balanced
- The table shows the distributional statistics over the lifetime of the contract for a floor of 50 and various cap levels.
- A floor and cap applied per hour reduce the variation more than a volume-weighted cap/floor per season

Hourly cap and floor

Floor	Cap	Average	P5	P10	P90	P95
no	no	127.27	56.16	67.27	205.57	252.34
50	no	133.18	68.36	77.00	207.01	252.51
50	500	129.34	68.36	76.99	202.33	240.30
50	250	116.93	68.34	76.25	171.00	186.01

Seasonal volume-weighted average cap and floor

Floor	Cap	Average	P5	P10	P90	P95
no	no	127.27	56.16	67.27	205.57	252.34
50	no	130.74	65.73	73.44	205.57	252.34
50	500	128.48	65.73	73.44	204.72	247.87
50	250	118.74	65.73	73.44	178.37	198.11

Beware of risk discounts in PPA prices!

Disadvantages PPAs

- Negotiation process complex
- Limited number of companies able to take PPAs
- Leads to steep discounts for “good” PPAs

Alternative: market based products

- Simpler products
- More liquidity
- More competitive price
- Disadvantage: more complex management, more residual risk

Case study

German PV owner

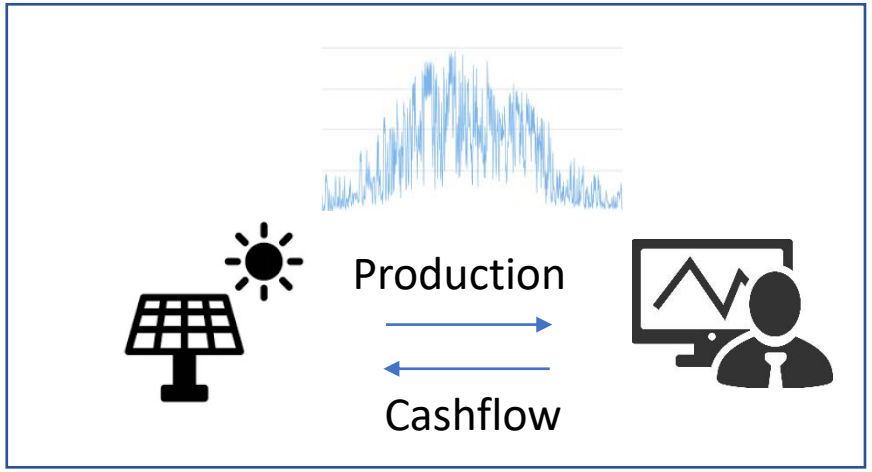
Asset owner wants to evaluate hedging possibilities

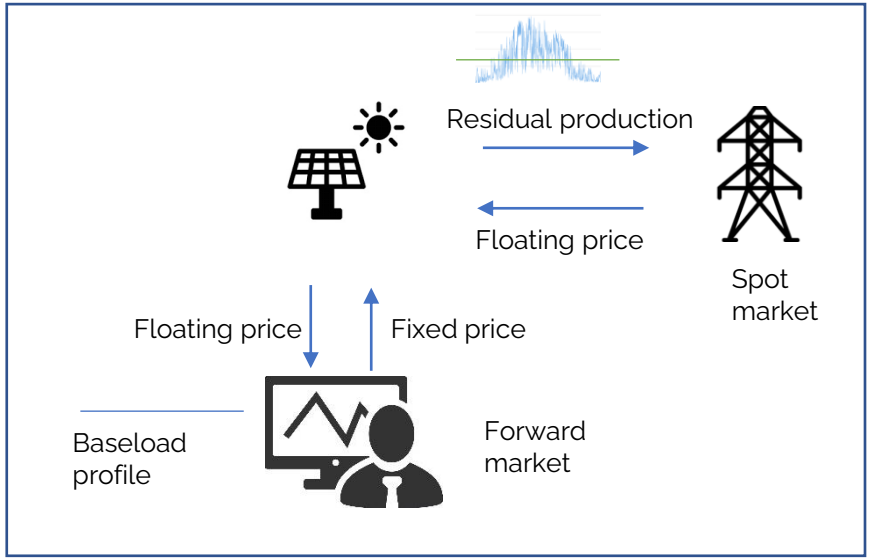
5 year reporting period

We analyze 3 different strategies

- Sell in market, no forward hedging
- Hedge with annual baseload hedge at fixed price (3 year horizon)
- Dynamic hedging

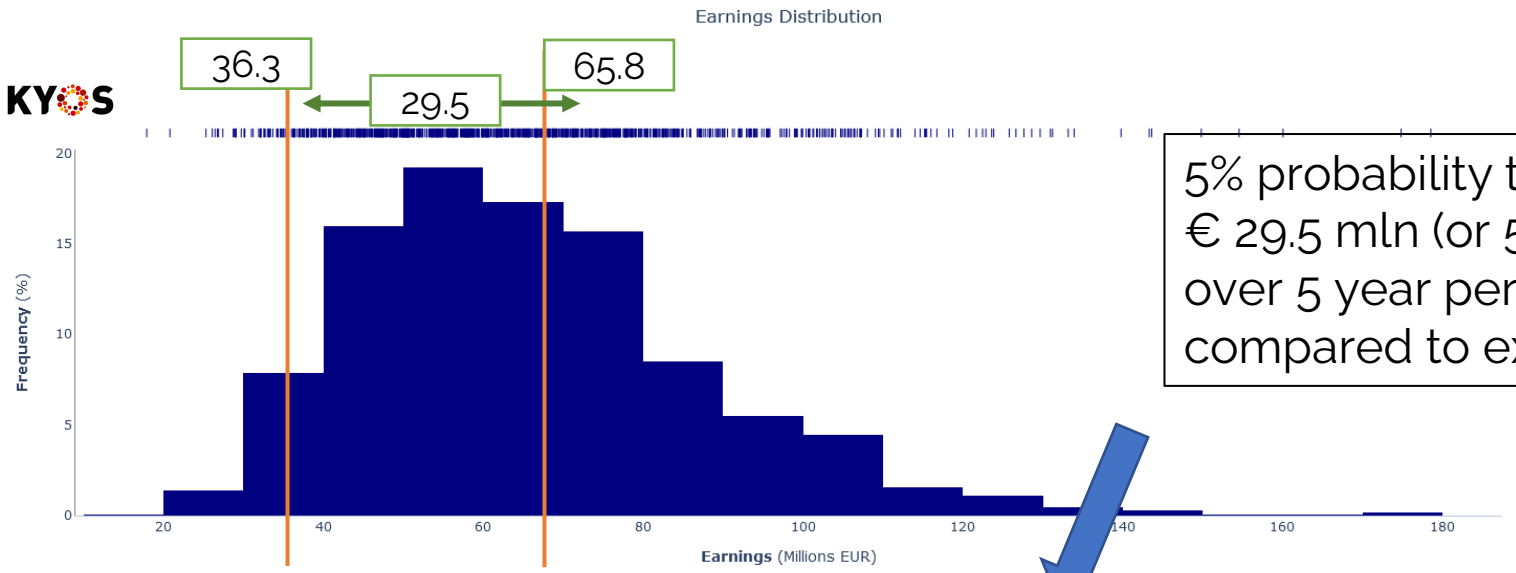
<u>Here: focus on total cashflow distribution</u>





Strategy 1 – results in high risks

We look at the distribution of earnings over a 5 year period (KYOS PPA software)

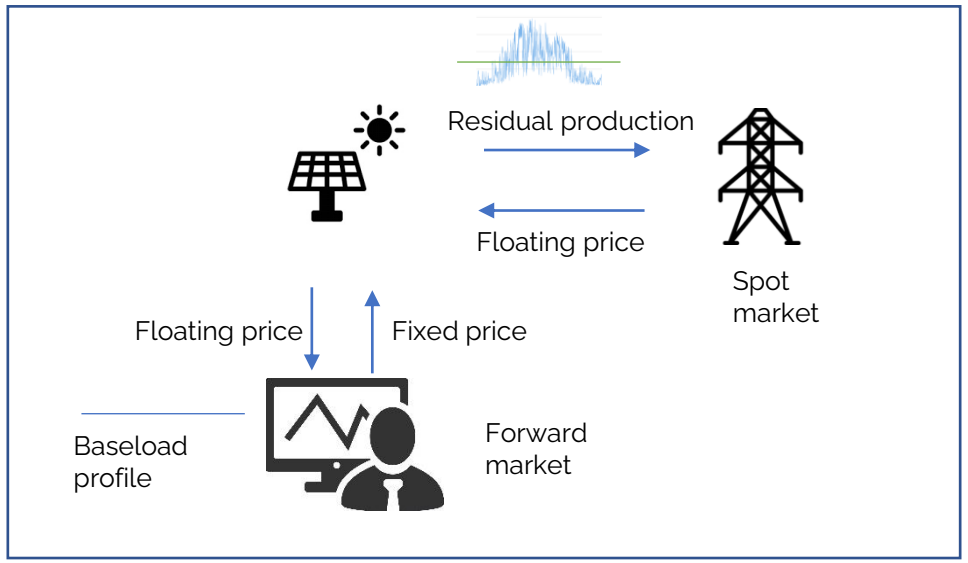


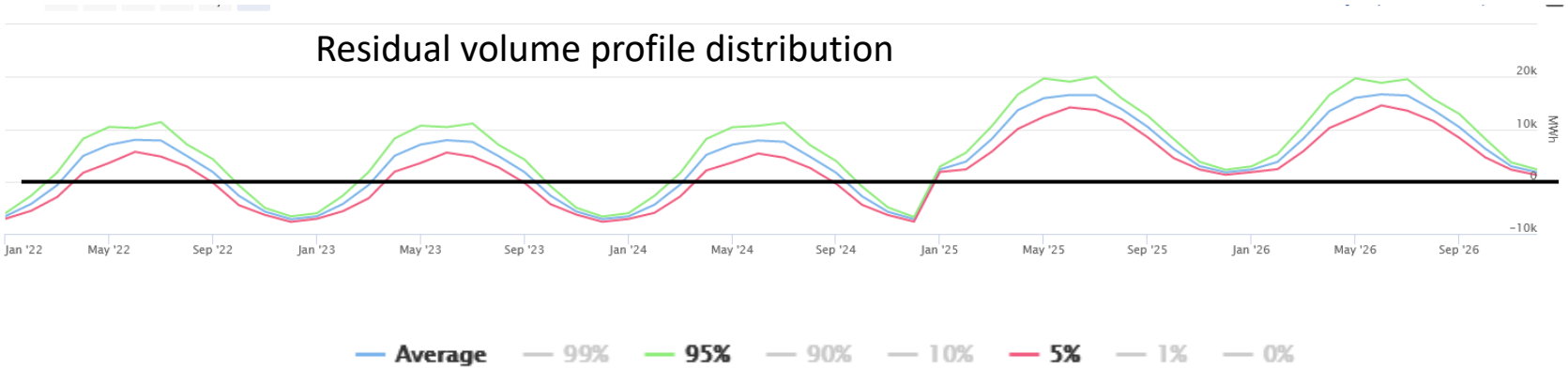
5% probability to lose € 29.5 mln (or 53 €/MWh) over 5 year period compared to expectation

Earnings at Risk Summary	Commodity	Currency	95% at Risk
Commodity	Total	EUR	29 518 769

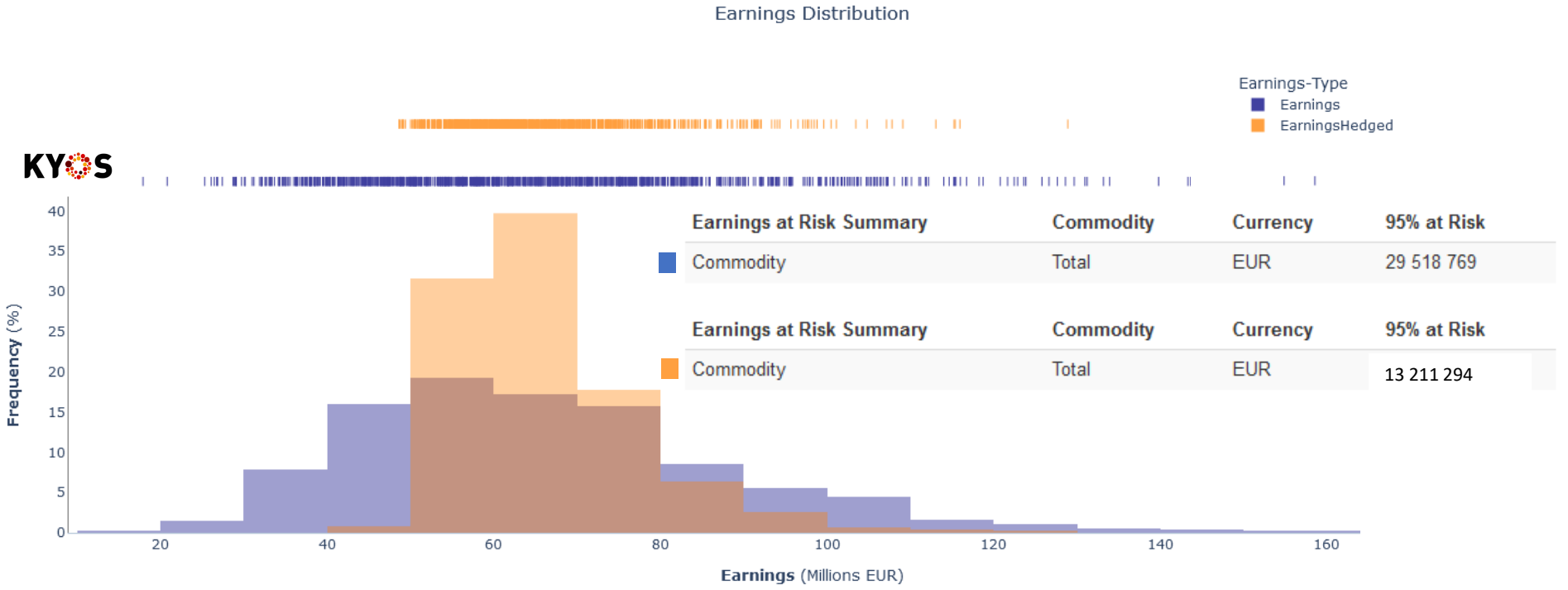
Strategy 2 – Hedge with annual baseload

- Asset owner sells fixed price, baseload, 3 year, value neutral hedge
- Main remaining risks:
  - Shape risk
  - Volume risk
  - Imbalance risk
  - Price risk after year 3





Strategy 2: lower risks



- We look at the distribution of earnings over a 5 year period (KYOS PPA software)
- Strong reduction of earnings risk:
  from 29.5 to 13.2 mln € for the 95% 'worst case' result.
- Main part of remaining risk in unhedged years 4+5
- Results can also be analysed per month: essential for cashflow/debt service planning
- Risk can be further reduced by using more advanced strategies, e.g. stack and roll

Strategy 3: stack and roll

Advantages

- Way to hedge price exposure of illiquid long-term periods
- Save on the risk discount in (structured / long-term) PPA contracts
- Intuitive approach

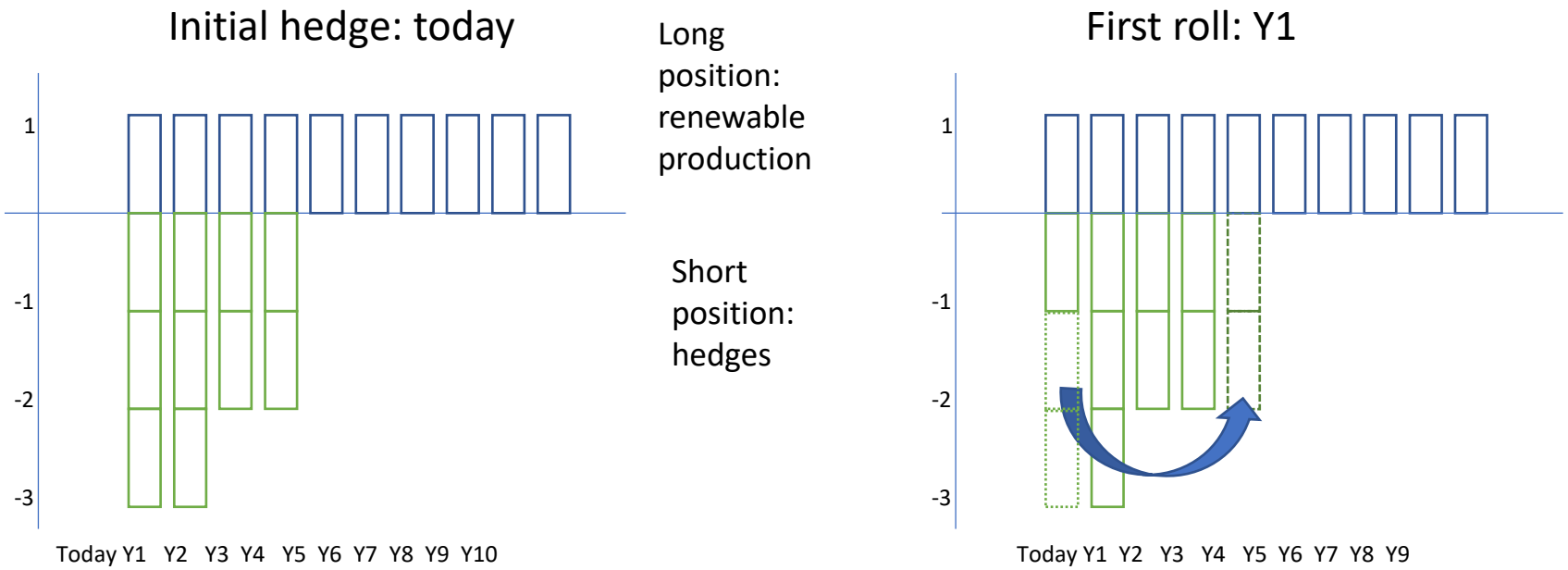
Disadvantages

- Requires enough liquidity in the forward market. Every year requires large position changes and you may be squeezed.
- Requires capital to deal with margin calls (MtM losses).
- Trading costs to make rolls each year.
- Risk of breaking correlations between the years. Example roll:
- Buy (back) 2023 year contract @ 100 €/MWh
- Sell 2025 year contract @ 60 €/MWh

How does stack and roll work?

Stack and roll strategy:

- Hedge illiquid periods with liquid periods
- Roll position when they become tradable
- In KYOS software: combined with dynamic position rebalancing for optimal risk reduction



Strategy 3: even better

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Earnings-at-Risk further reduced from 13.2 to 9.9 mln €

More positive: number of 'bad' scenarios is much lower

Earnings at Risk Summary	Commodity	Currency	95% at Risk
Commodity	Total	EUR	9 932 380

Conclusion

- Market moving to a merchant world
- Risk management has become a necessity
- Requires an integrated solution dedicated to renewable energy assets and contracts to:
  - Monitor these risks
  - Decide what hedges can lower the current risk
  - Get to a portfolio view of risks

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Contact Details

We look forward to supporting you with the right tools and advice!

KYOS

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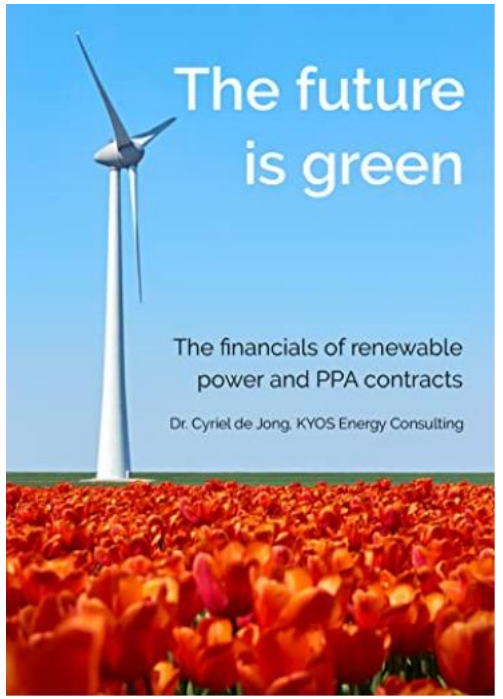

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