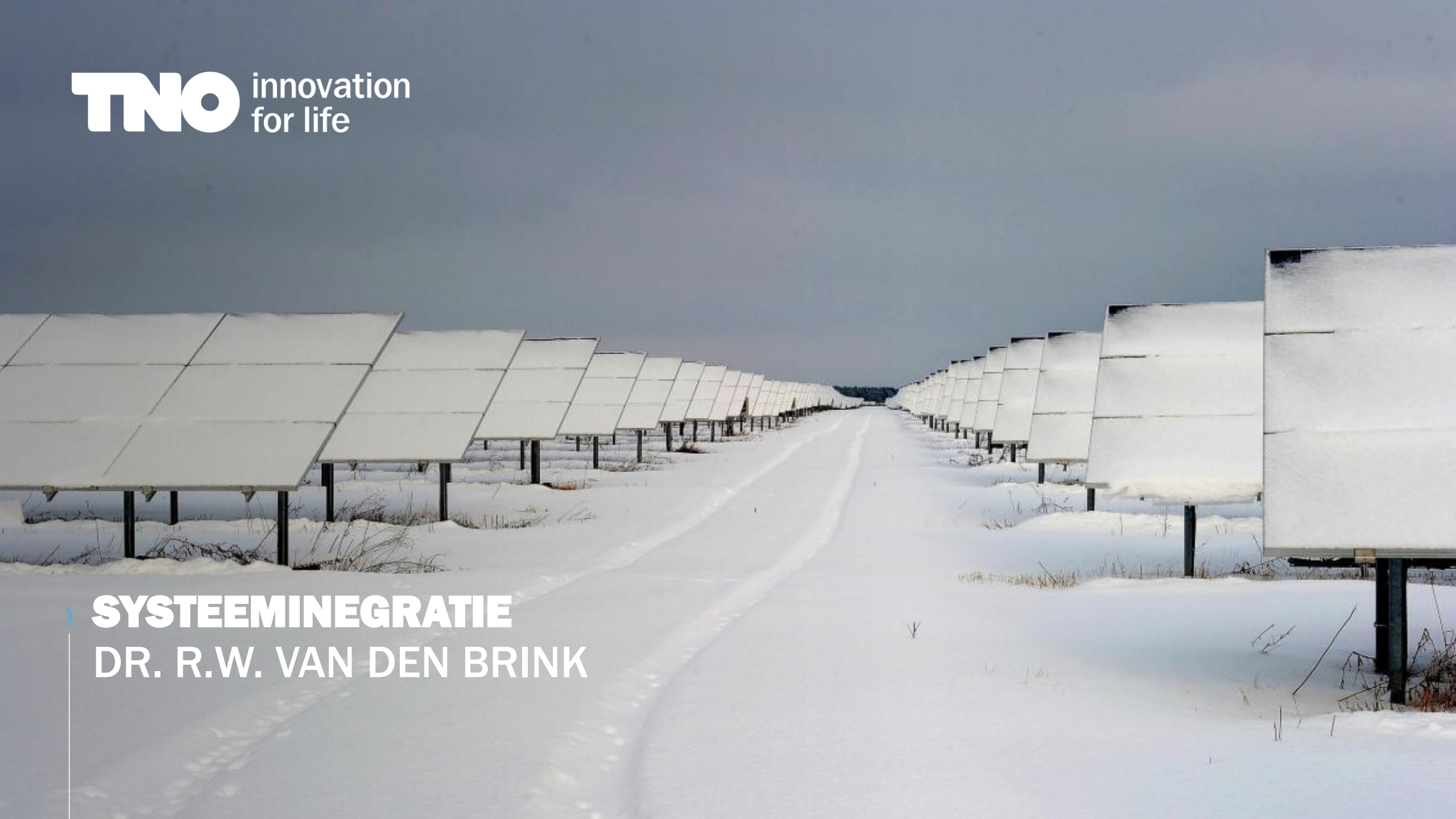
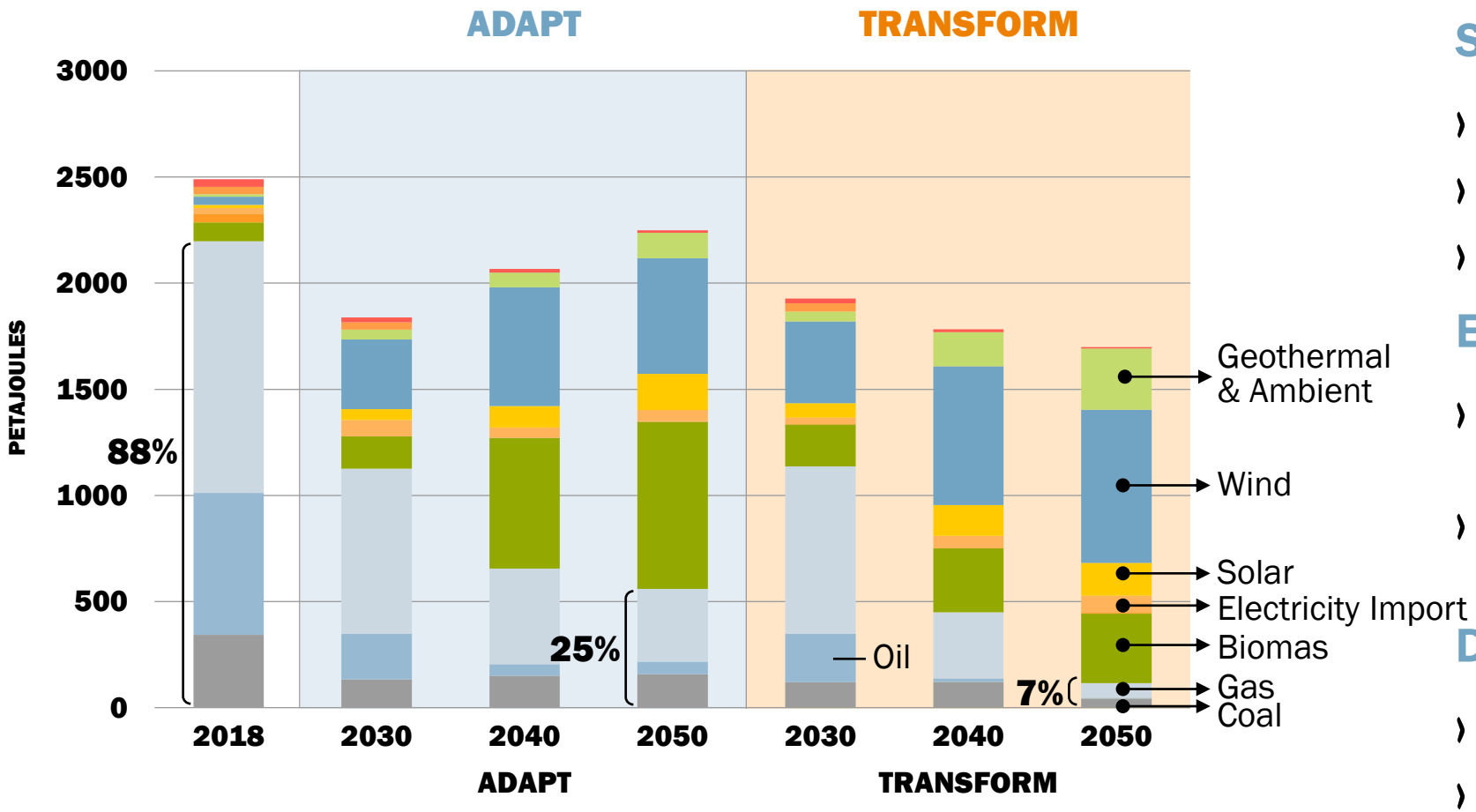
TNO innovation for life



SYSTEEMINEGRATIE

DR. R.W. VAN DEN BRINK

TNO ENERGY SCENARIO'S
FOR A CO_2-NEUTRAL ENERGY SYSTEM IN 2050



SCENARIO STUDY

- OPERA model
- Cost-optimised energy systems
- Within boundaries

ELECTRIFICATION

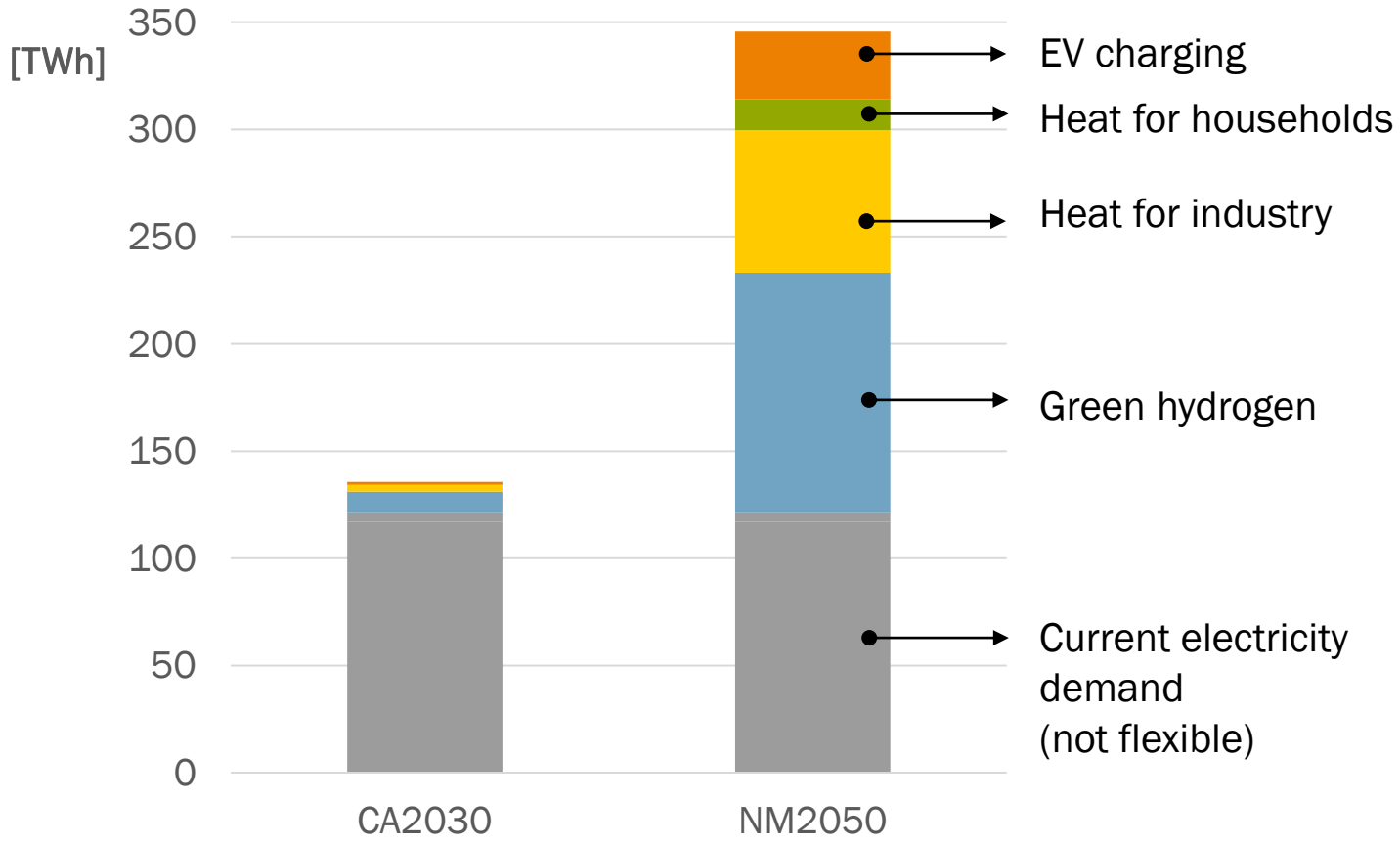
- Offshore wind and solar dominant
- Hydrogen limited, but crucial role

DIFFICULT SECTORS

- Fuels for aviation and shipping
- Heat in industry and households

TNO innovation for life

SYSTEM INTEGRATION OF WIND AND SOLAR
ELECTRICITY DEMAND IN 2030 AND 2050 NETHERLANDS



ELECTRICITY MARKET R&D

- COMPETES model
- Matching demand and supply

DEMAND RESPONSE

- Major option for balancing energy system

BIG QUESTIONS

- What is needed to make the demand flexible?
- Role of energy transport infrastructure?

EXAMPLE:
FLEXIBLE CHARGING OF ELECTRIC VEHICLES

- Smart charging is a very cost-effective way of dealing with variable electricity supply
- Requirement: cars must be connected to the grid when they are not used
- However:
  - Technical progress: charging has become much faster
  - Only 20% of house holds can charge at home
  - Municipalities reluctant to create public charging
  - Distribution net might get overloaded
  - Incentive for consumers is relatively small

EXAMPLE:
DEMAND RESPONSE IN INDUSTRY

- Industry plays a crucial role, because of high energy demand
- Requirement: new industrial processes must be able to respond to supply profiles
- However:
  - Business cases are based on 8000 operating hours per year
  - Companies have to decide: revamp or relocate?
  - Many electricity-based processes are still in development
  - Storage of products rather than electricity

SYSTEM INTEGRATION
RESEARCH NEEDS

- The energy transition is a system transition
  - Behavioral change of individual consumers, residents and companies
  - Impacts on other domains: spatial planning, decision making, market regulation, social
- System integration of wind and solar on national energy system level
  - Production profiles match quite well: improve flexibility in production of wind and solar
  - Exchange with other countries
  - Demand response is most cost-effective option: technologies and societal research
  - Production and storage of green hydrogen: lower costs, large-scale storage
  - Storage of electricity: compressed-air, batteries
- System integration on regional and local level
  - Mitigate distribution net issues
  - Use power where it is produced
  - New regulations, peer-to-peer, ICT tooling