Ricardo-AEA

Basic Principles of Inventory Preparation and Projections

27 January 2015

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Ricardo-AEA: Who we are

- Internationally-renowned consultancy
- Heritage of world-leading scientific/technical capability
- Providing analysis and solutions for major environmental challenges
- Client base of international governments and businesses
- Headquartered at Harwell Science Park, near Oxford
- Over 400 scientists and technical staff
- Part of Ricardo PLC

Our international projects

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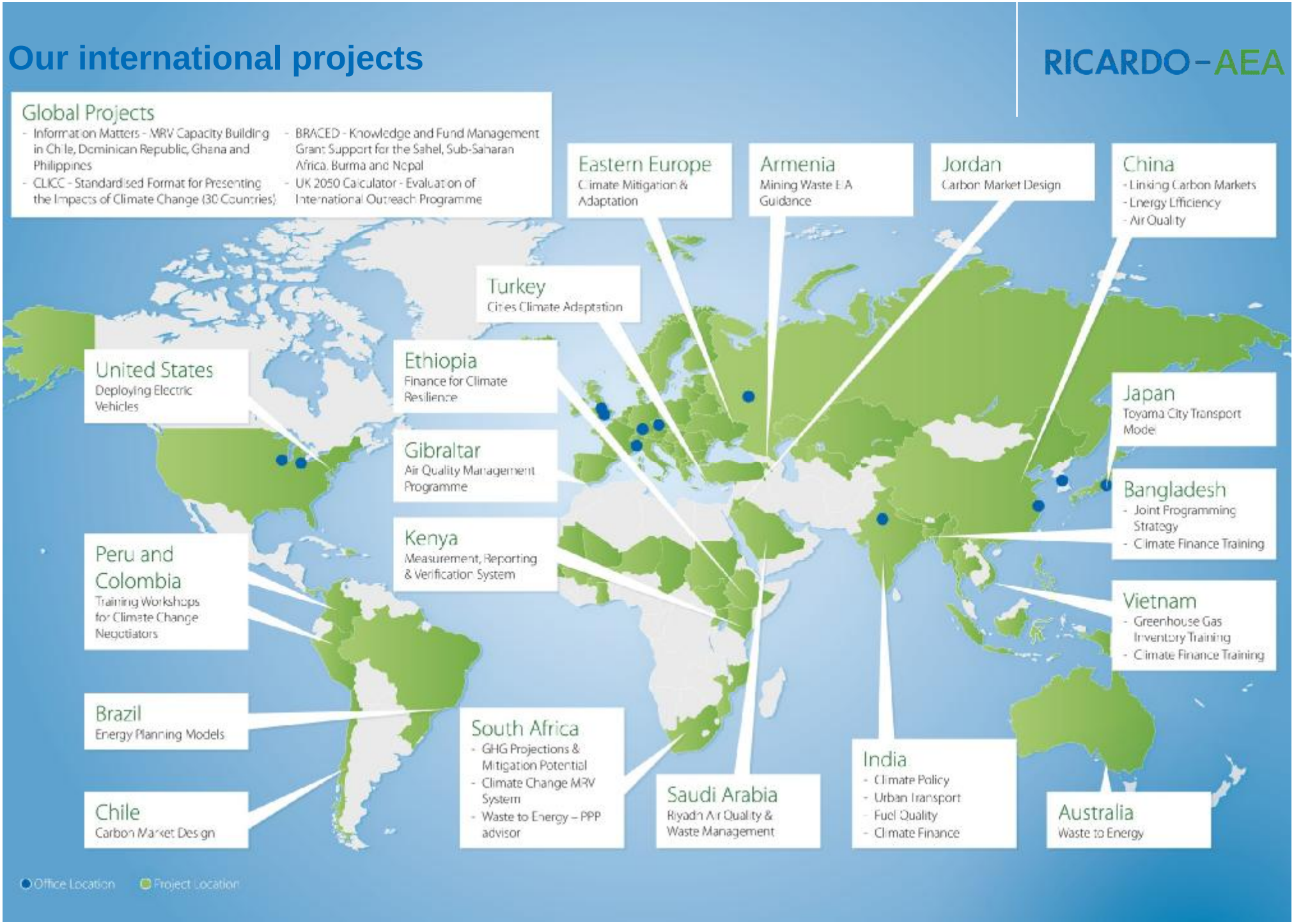


Right or Wrong?

1. GHG Inventories are used to calculate emission reductions **WRONG**
2. GHG Inventories are only of use to the UNFCCC **WRONG**
3. A GHG Inventory is only useful it it is perfect **WRONG**
4. A good GHG inventory requires support from all sectors of the economy **RIGHT**
5. GHG Inventory calculations are quite simple **RIGHT**
6. Inventories are best done on a project basis **WRONG**
7. There is plenty of guidance available for the set-up of GHG inventories **RIGHT**
8. Projections are not connected to GHG inventories **WRONG**
9. There is only one standard approach to develop projections **WRONG**
10. Projections can be presented in the form of different scenarios **RIGHT**

At the end of the course you will understand:

- Why having a GHG inventory is useful
- What basic approaches of GHG inventory calculation are
- Who needs to cooperate in order to create a GHG inventory
- What long-term structures are needed
- How GHG inventories and projections are connected
- What different types of models for projections exist
- How the model LEAP basically works

This is my colleague John Watterson, who works with the UNDP project on the GHG Inventory

Purpose of National GHG Inventories

Figure 2-1 Trend in greenhouse gas emissions by gas (1990 = 100)

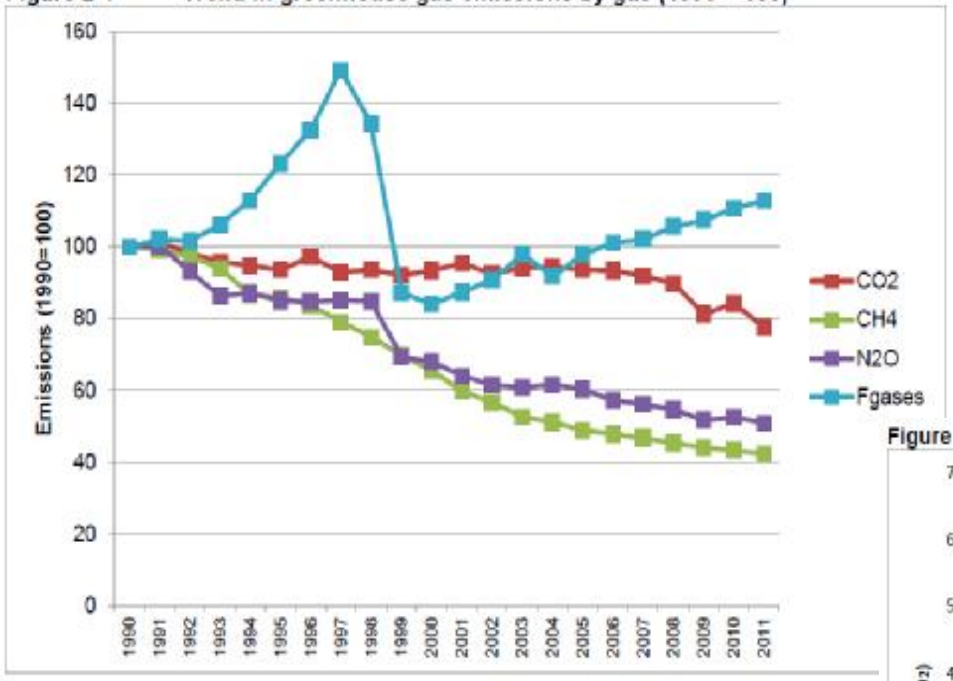
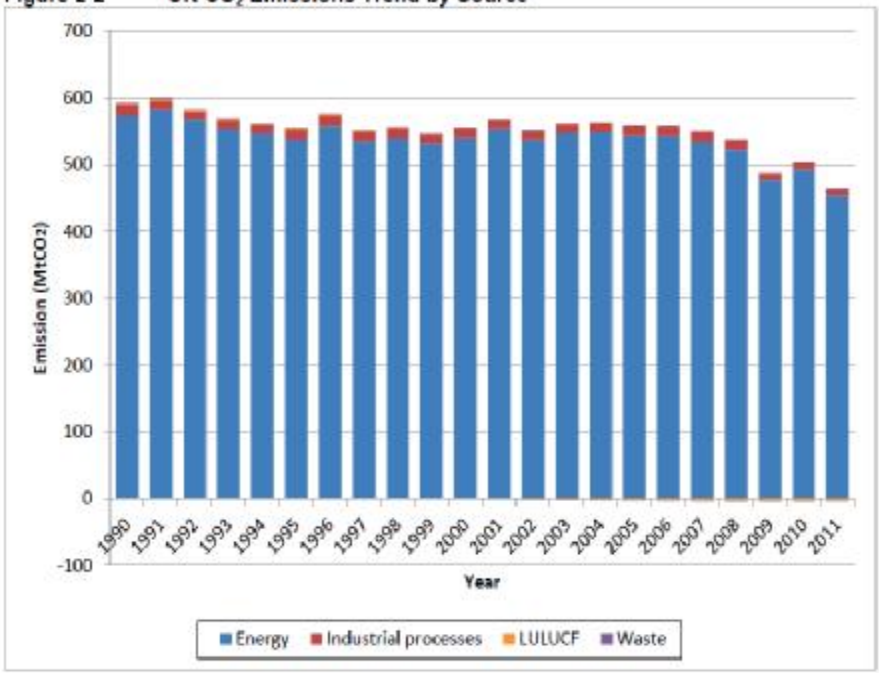


Figure 2-2 UK CO_2 Emissions Trend by Source



- Show development of GHG emissions at national level over time
- Allow prioritising of sectors, sources or gases for mitigation action
- But there is more.....

Further uses of GHG Inventories

There is a wide audience of stakeholders...

- Decision makers and policy advisors
- International climate change community
- Provincial and local agencies
- The public and interest groups (e.g., Non-Government Organisations)
- Businesses
- Scientists and academics

Scope of a national GHG inventory

- A **greenhouse gas inventory** is an accounting of **greenhouse gases** (GHGs) emitted to or removed from the atmosphere.
- An inventory will list, by source, the amount of GHGs emitted to the atmosphere during a given time period (annual emission estimates from a base year to the latest year).
- **Gases**: *Carbon dioxide, methane, nitrous oxide, HFCs, PFCs, SF_6*
  - Carbon dioxide: mainly from combustion of fuels in different economic sectors, industrial processes, LULUCF sources and sinks
  - Methane: waste, agriculture
  - Nitrous oxide: industrial processes, agriculture
  - F-gases: industrial processes & AC/Refrigeration
- **Excluded**:
  - Short-cycle biocarbon in the GHGI (e.g. CO_2 from plant biomass)
  - International shipping and aviation – reported as “memo items”.

Inventory Emission Sectors

Energy



Agriculture


Industrial Processes, Solvents

Waste

Land Use, Land-Use Change and Forestry


Emission Estimation in the GHGI

- Follow the IPCC Guidelines and Good Practice Guidance
- Basic estimation approach
  Emissions = Activity Data * Emission Factor
- Method tiers *(higher tier = greater accuracy):*
  - ü Tier 1 – Default approach
    national activity data * IPCC default emission factor
  - ü Tier 2 – Country-specific
    national activity data * country-specific emission factor
  - ü Tier 3 - Installation specific data or country-specific models

Emission Estimation in the GHGI: summary of sources

- **Activity Data (AD) Sources**:
  - National statistics
    - Energy balance
    - Production statistics
    - Population data / housing data
  - Industrial / commercial / public surveys / censuses
  - Bottom-up data e.g. from industrial installations or trade associations.
  - Proxy data (even from other countries)

- **Emission Factor (EFs) Sources**:
  - International defaults
  - Country-specific factors
  - Use of data from other countries with similar national circumstances
  - IPCC Emission Factor Database.

Resources

There are lots of available resources that can be accessed (aside from IPCC GLs and GPG) and a wide community of expertise to engage with, e.g.:

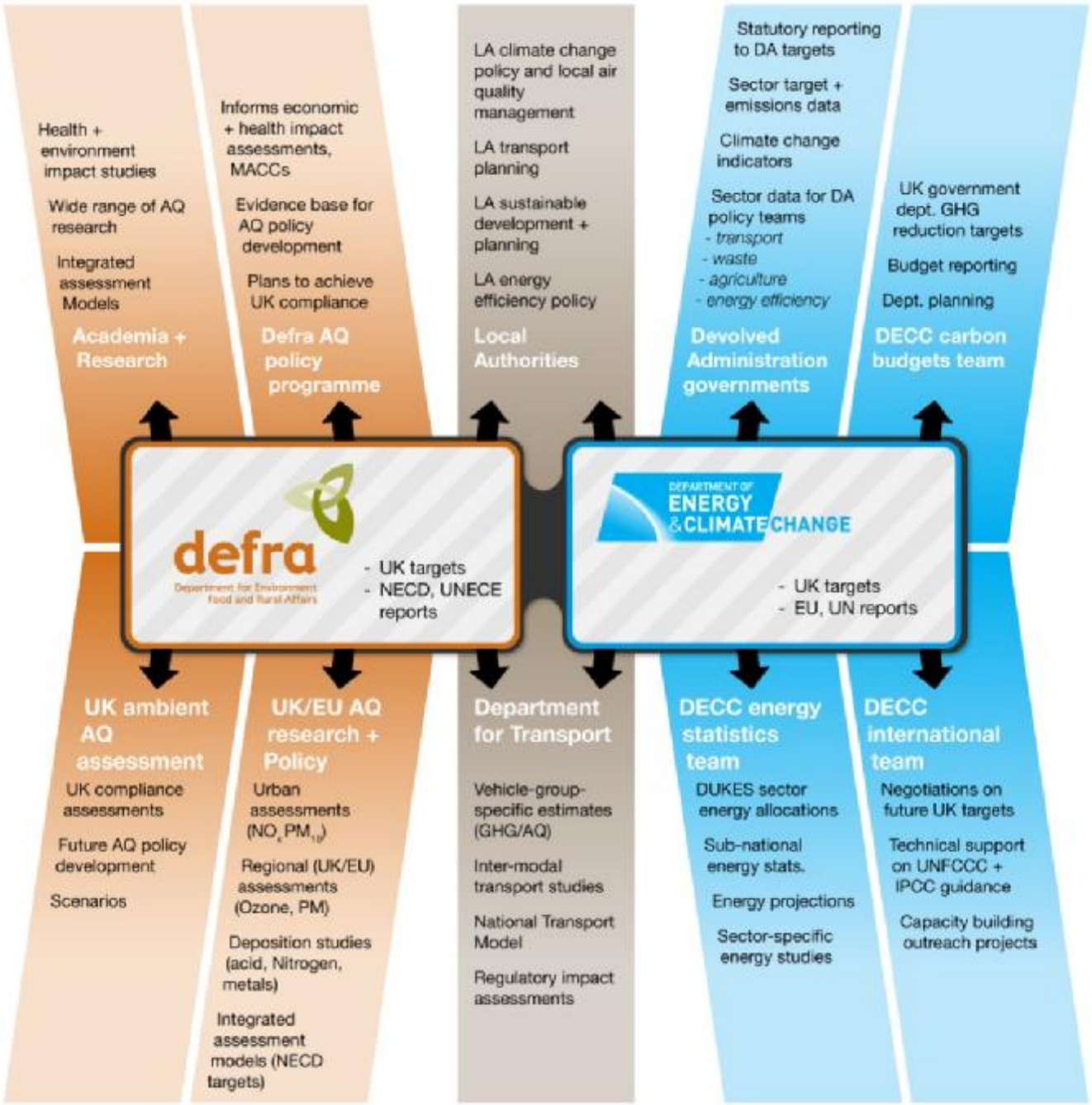
- National Statistics Agencies
- Sectoral experts, stakeholder organisations
- Other national experts
- IPCC Emission Factor Database
- Other international experts, other country inventory experts, regional centres of excellence
- International organisations publishing statistics e.g., United Nations, FAO, the International Energy Agency, OECD and the IMF
- Reference libraries (National Libraries)
- Scientific and technical articles in environmental books, journals and reports.
- Universities
- National Inventory Reports from Parties to the United Nations Framework Convention on Climate Change

What data do we really need to collect?

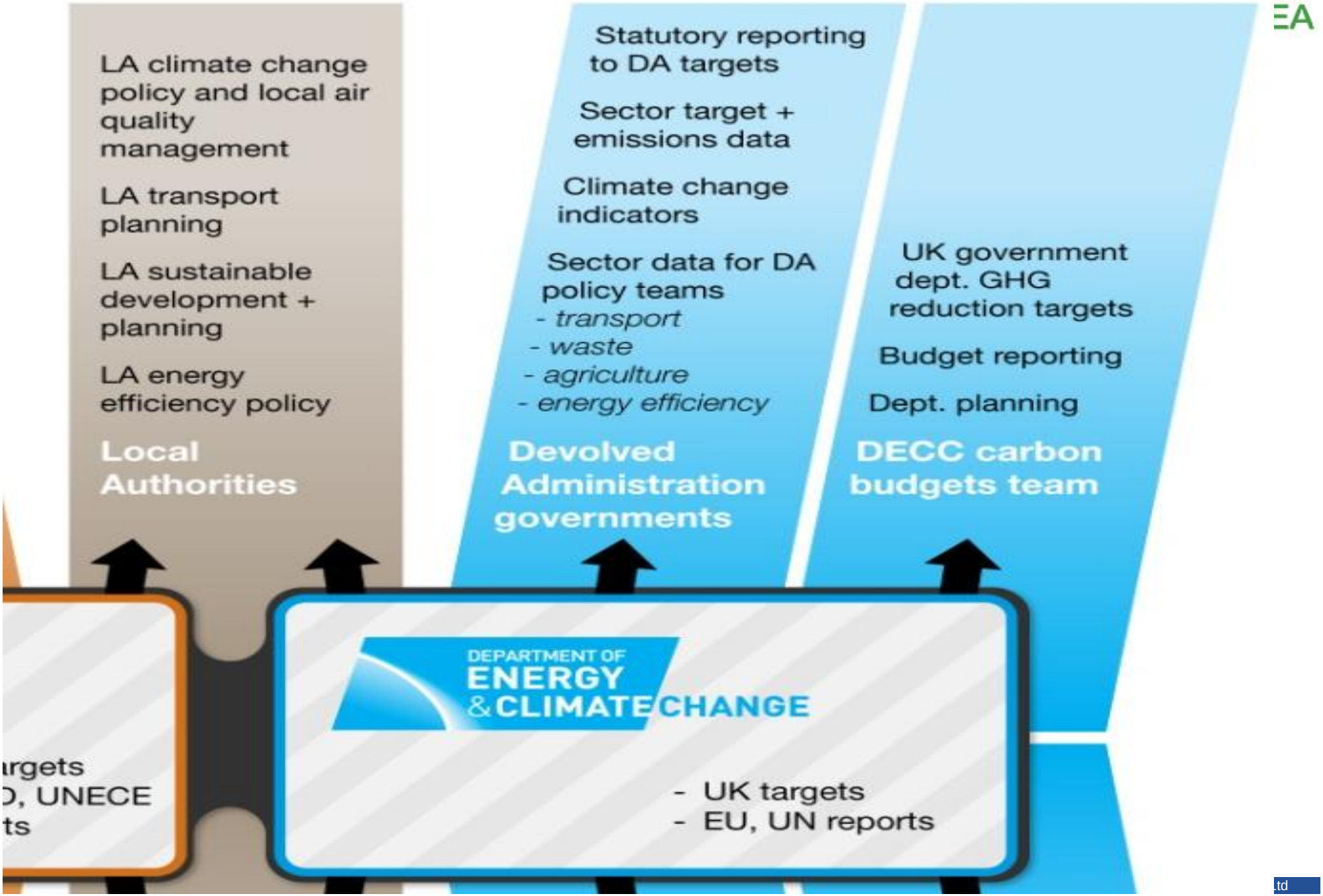
- **Energy sector**
  - National energy balance
  - Fuel compositional data (carbon content)
  - Stationary combustion technology stock information: industry, commercial, domestic
  - Vehicle fleet statistics, air traffic movements, rail and shipping data
  - Fuel production, processing, delivery (solid fuels, oil and gas, petroleum fuels) – *for fugitive emission estimates*
- **Industrial processes**
  - Industrial production data: minerals, chemicals, metals...
  - Site-specific info.: emission measurements, process design, abatement
  - Refrigeration and air-conditioning units (how many, how big, what fluids used, how old, unit lifetime, unit refilling frequency..?)

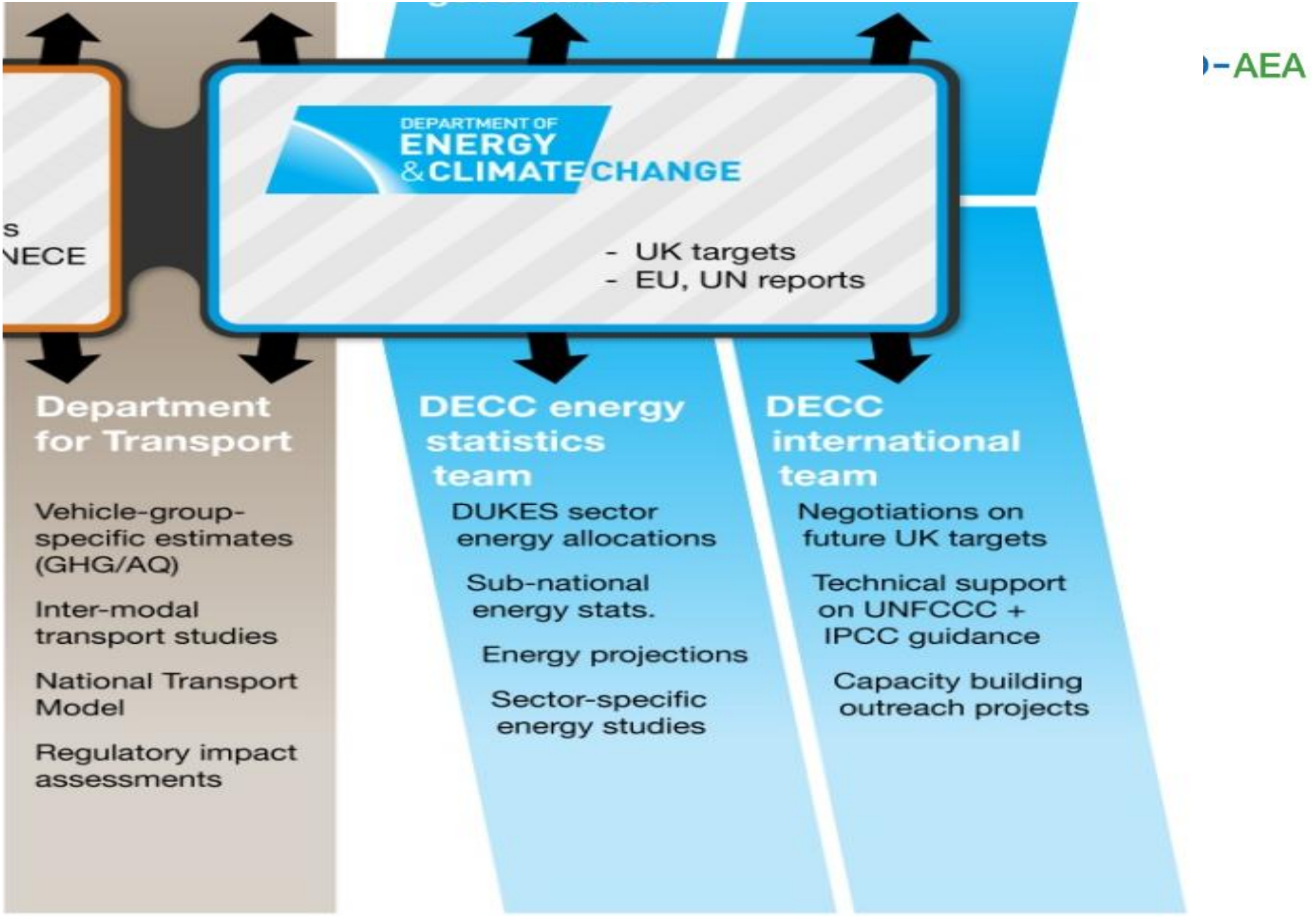
What data do we really need to collect?

- **Agriculture**
  - Annual crop production data
  - Livestock numbers
  - Farm management practices (waste mgmt., fertiliser use etc.)
- **Land Use, Land Use Change and Forestry**
  - Land use maps / annual estimates by type / land use rotations
  - Forestry type, areas, management practices
  - Harvesting data, stock models
  - **Waste**
    - Waste arisings: compositional analysis, annual amounts
    - Waste management practices: landfills / incinerators / open burning

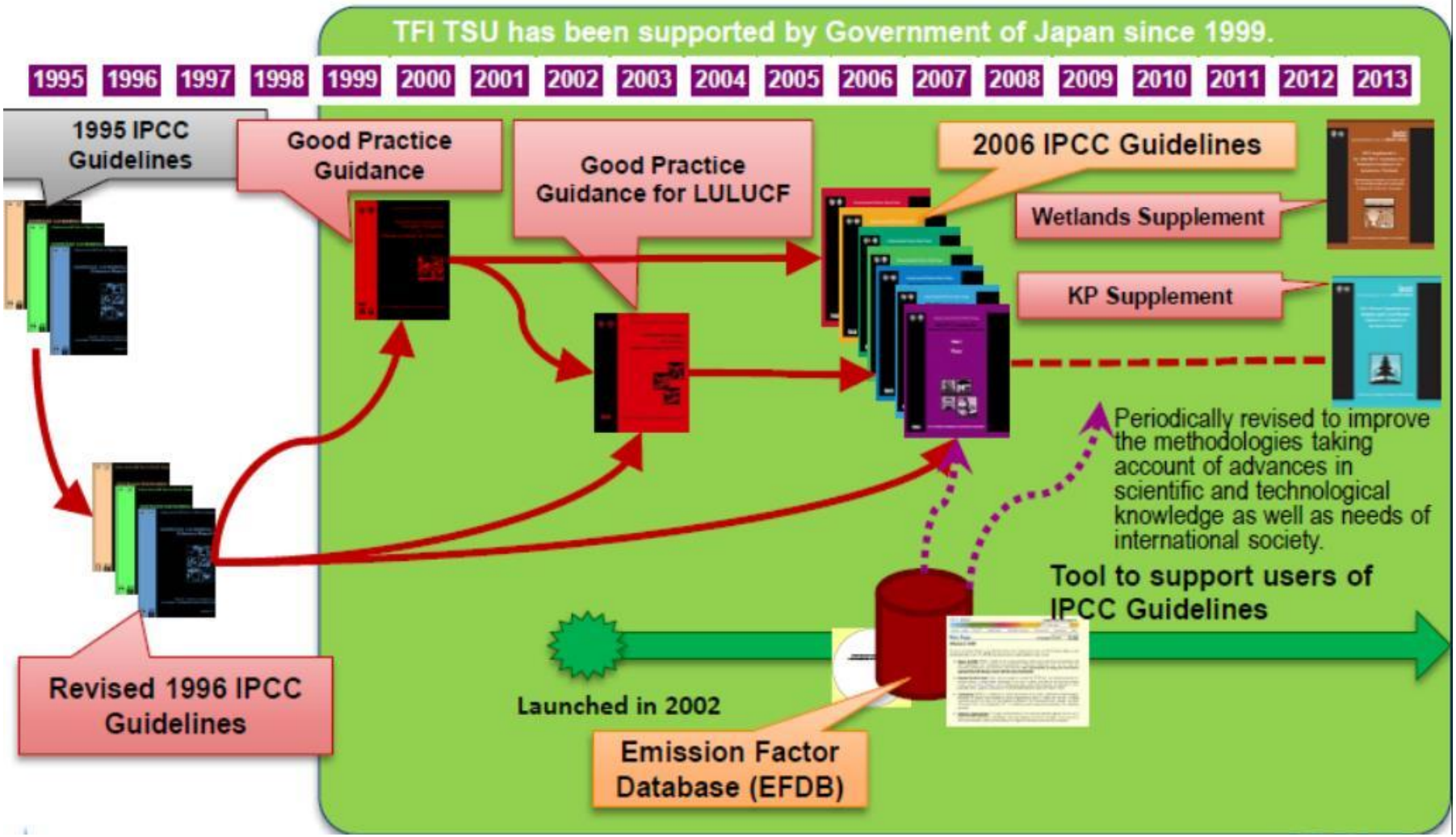


Use of inventory data and inventory experience in the UK


LA climate change policy and local air quality management
LA transport planning
LA sustainable development + planning
LA energy efficiency policy
Local Authorities
Statutory reporting to DA targets
Sector target + emissions data
Climate change indicators
Sector data for DA policy teams
- transport
- waste
- agriculture
- energy efficiency
Devolved Administration governments
UK government dept. GHG reduction targets
Budget reporting
Dept. planning
DECC carbon budgets team
DEPARTMENT OF ENERGY & CLIMATE CHANGE
- UK targets
- EU, UN reports



Evolution of IPCC Guidelines & other tools



Source: IPCC

IPCC Inventory Software

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http://www.ipcc-nggip.iges.or.jp/software/

02/02/2015

A ‘Quality’ Inventory

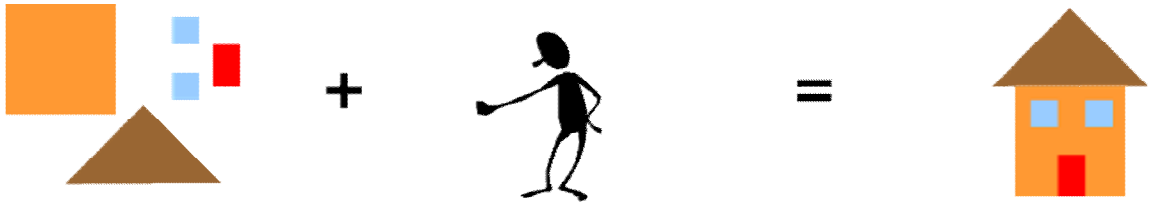
National GHG inventories must be prepared in accordance with the UNFCCC **data quality principles (TACCC)**:

- **Transparency**
- **Accuracy**
- **Completeness**
- **Comparability**
- **Consistency**

Tools: Quality Control / Quality Assurance (QA/QC) and a continuous improvement process

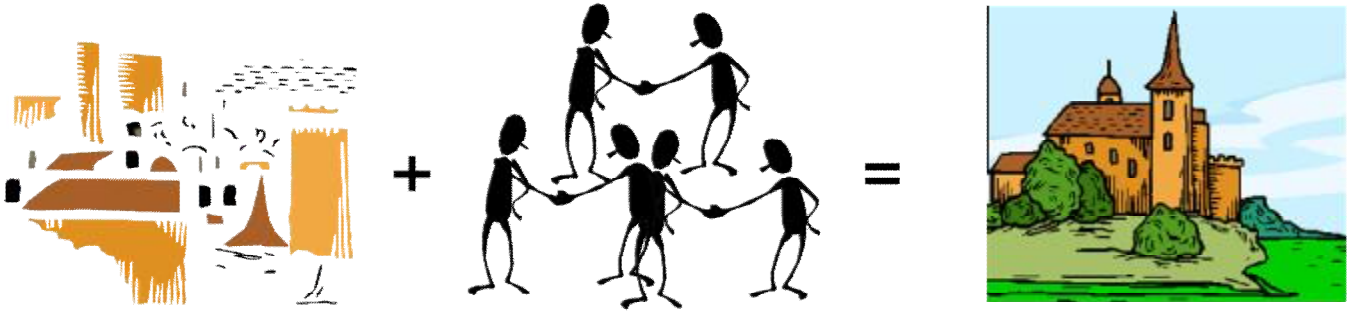
Inventory development: from simple to complex…

Year 0



Year ~5

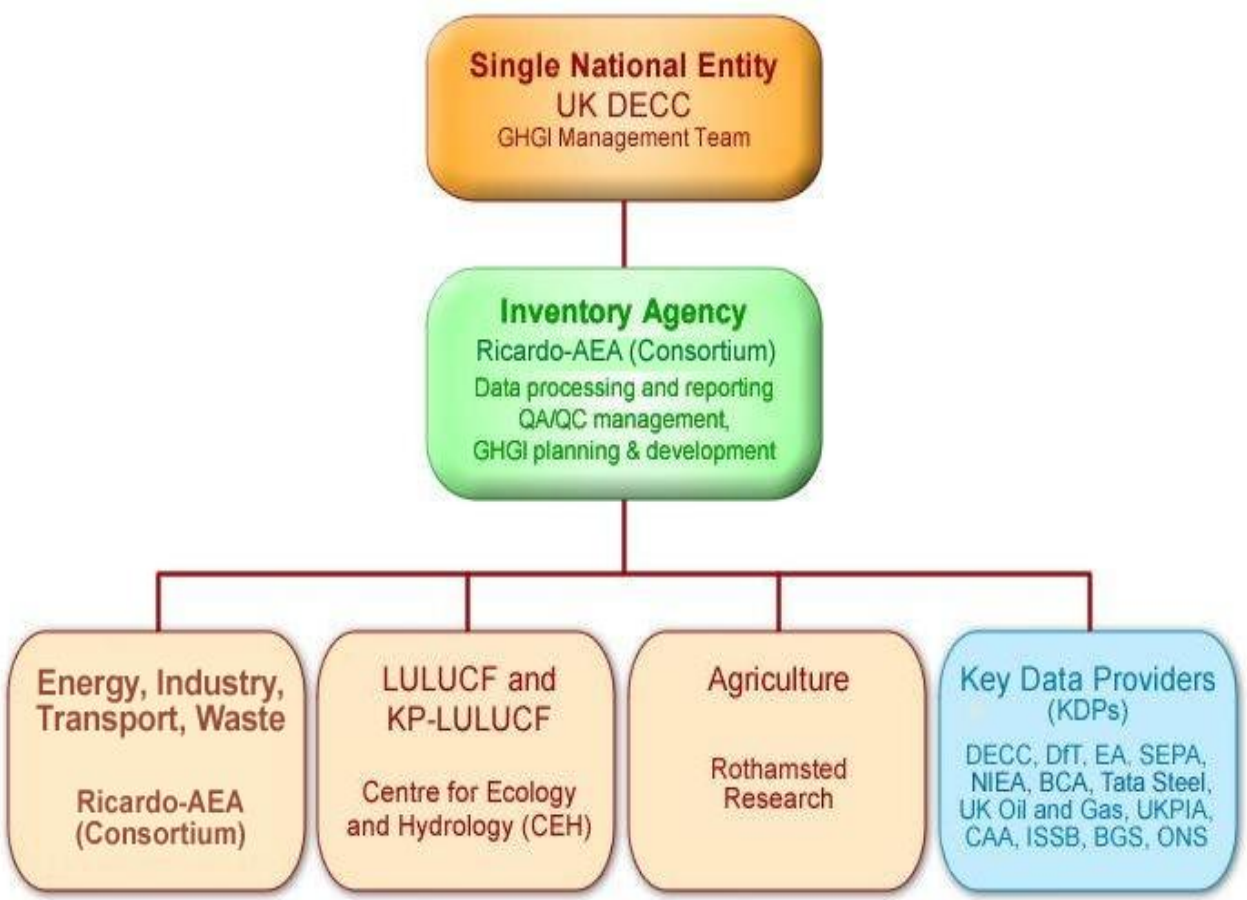
Year ~10



National Arrangements – what are they for?

- To ensure **continuity** through the development of national **capacities and capabilities**
- To ensure the **sustainability** of the GHG preparation process:
- Will also help with the regular preparation of biannual reports in accordance with relevant decisions under the UNFCCC process.
- To **inform** international, national and local **policy making**.
- To foster **consistent estimation approaches** across government agencies and offices.
- To **coordinate responses** to requests for information.
- To ensure **high quality** and objective inventory information.

Key organisational structure of UK National Inventory System



Key Organisations

Single National Entity

A **single national entity** to be responsible for the overall inventory, to:

- **Arrange with collaborating entities** that contribute data, research, estimate emissions or provide expert reviews
- **Act as the legal authority** to collect and disseminate data necessary for the preparation of the inventory
- **Ensure inventory processes** are in compliance with COP decisions
- **Define and apply procedures** for collecting data, preparing inventory, communicating results, submitting report and archiving
- **Liaise** among government departments, national agencies
- **Ensure the implementation of QA/QC.**

What do you need?

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Institutional Elements

- Responsibilities / roles for data collection, inventory compilation, QA/QC, reporting agreed
- Long-term budgets for inventory related activities
- Reliable access to data sources

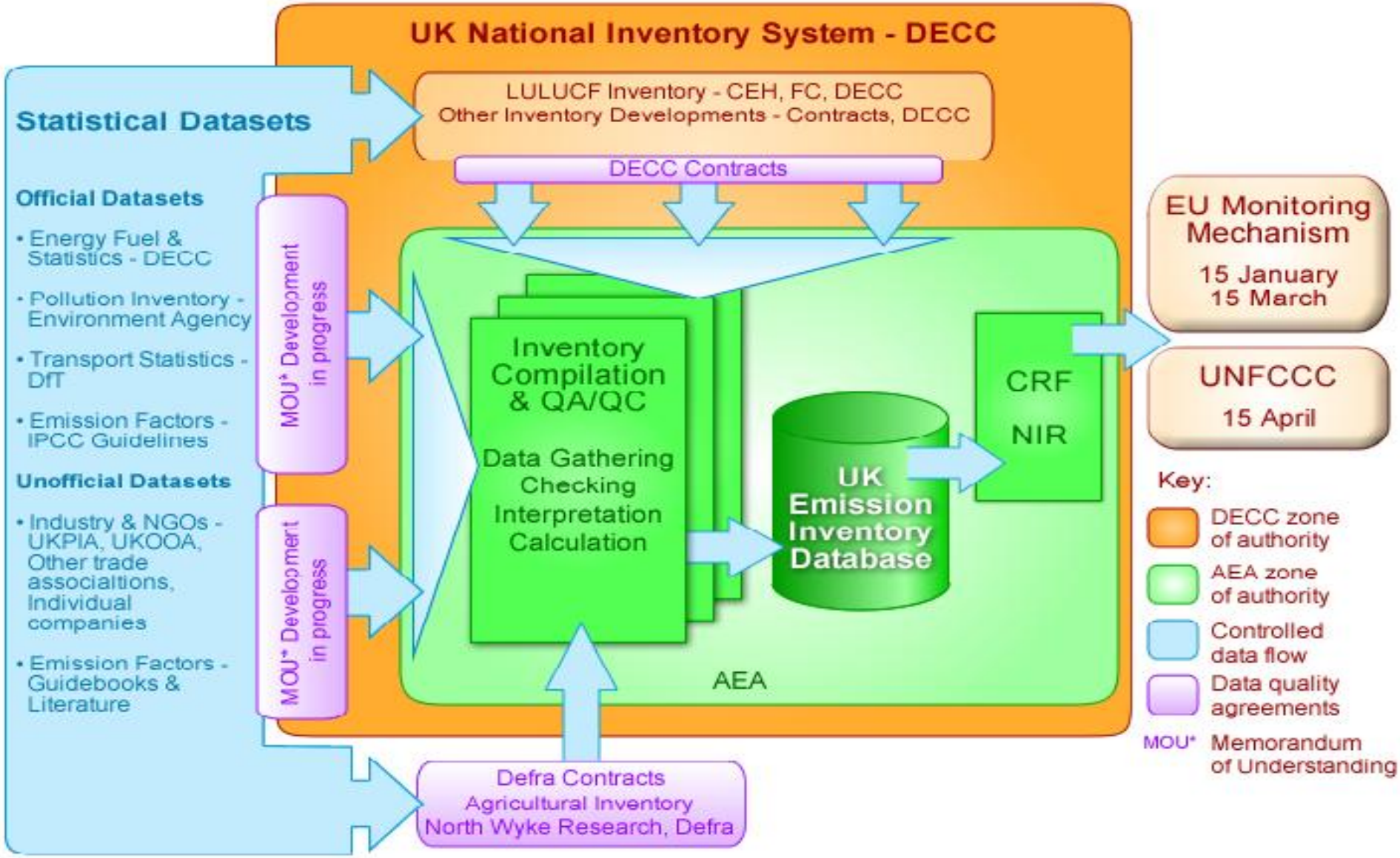
Capacity-related elements

- Sectoral experts understanding methodologies, data, QA/QC
- Compilation team, understanding UNFCCC reporting requirements, QA/QC, data handling and archiving processes

Technical elements

- Emission calculation methodologies
- Defined processes for data collection, emission calculation, data storage, report generation, QA/QC, long-term inventory improvement
- Tools for data processing and data archiving (e.g. MS Excel)

In more detail: UK National System for the GHGI



Steps to a National Inventory System

1. **Identify all institutions** to be involved:

- Appoint national inventory agency
- Allocate responsibilities for inventory preparation and management
- Define formal approval process within government.

2. Develop schedule:

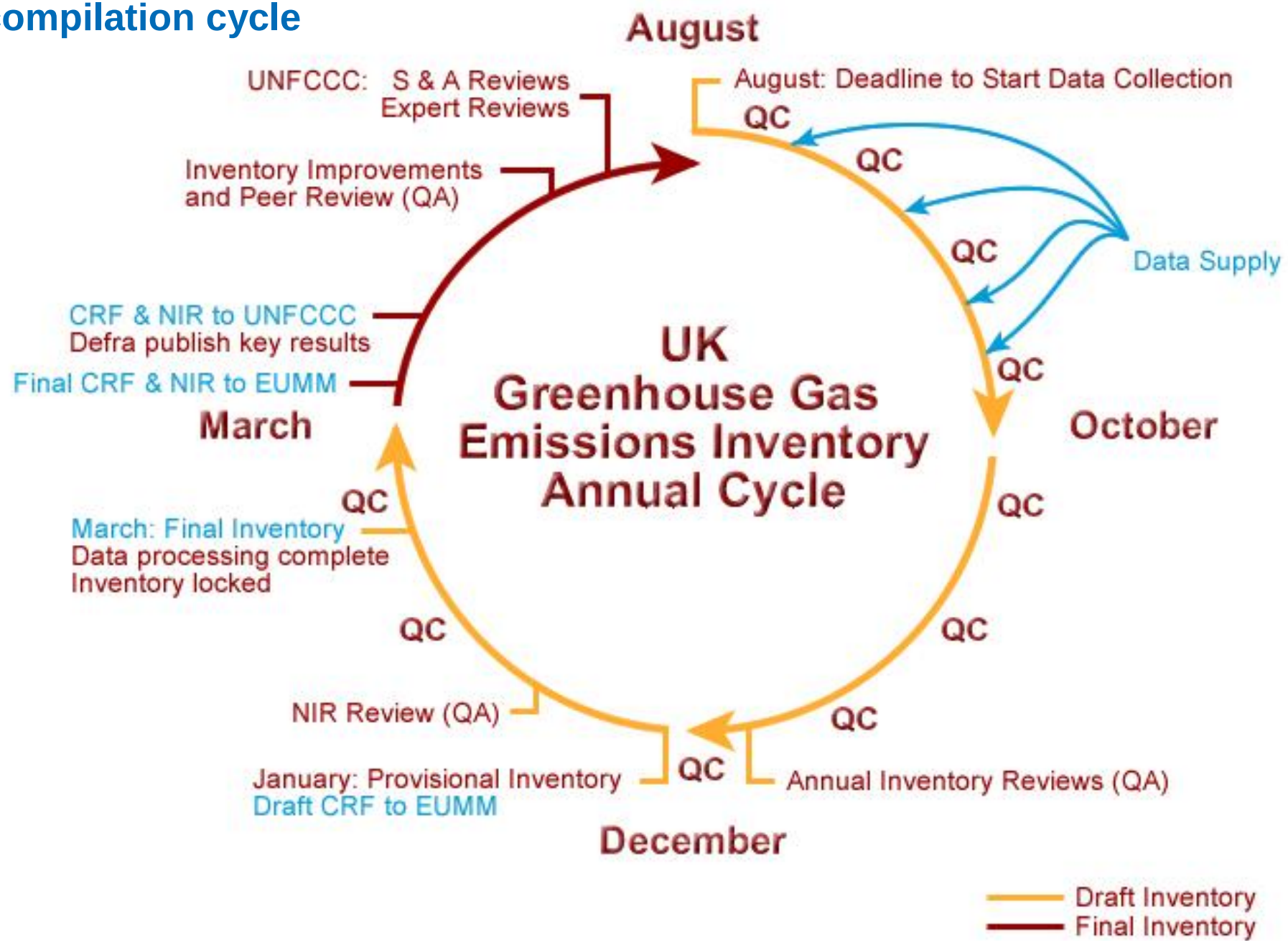
- Timeframe and specific milestones
- Make arrangements to collect data from statistical agencies, companies, industry associations, etc.

3. Create QA/QC plan.

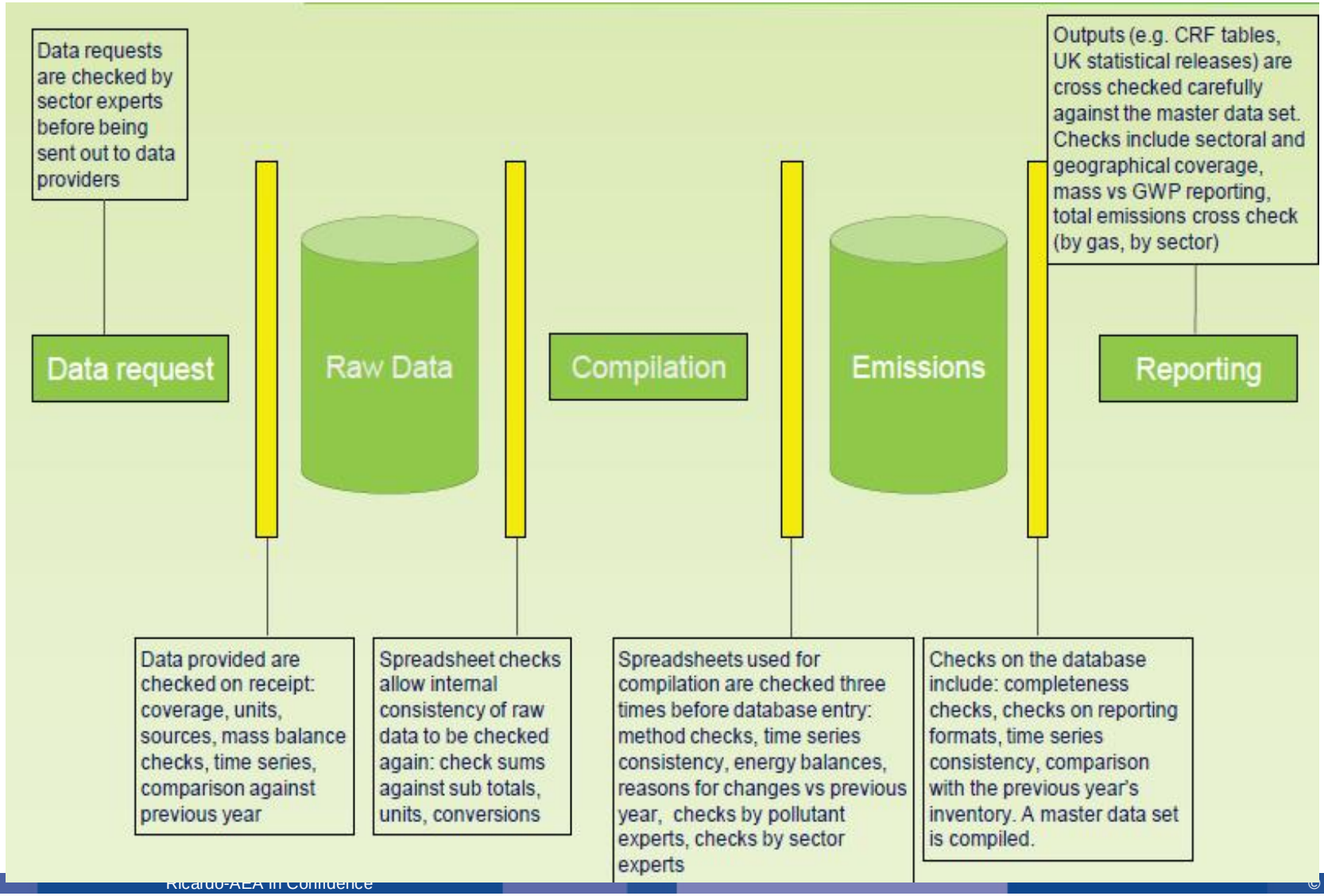
4. Integrate continuous improvement.

5. Reporting

Example: UK Annual inventory compilation cycle



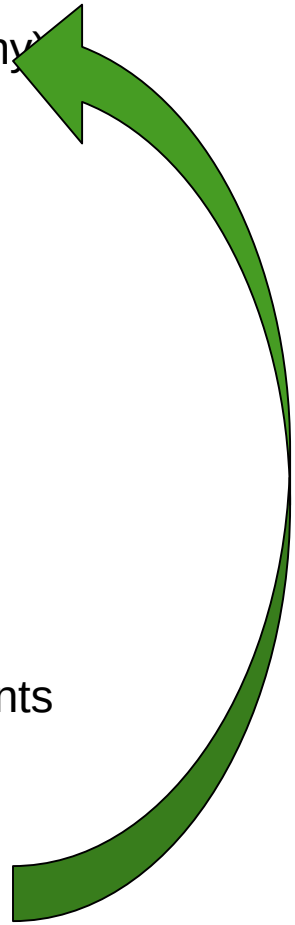
QA/QC of data gathering in the UK Inventory



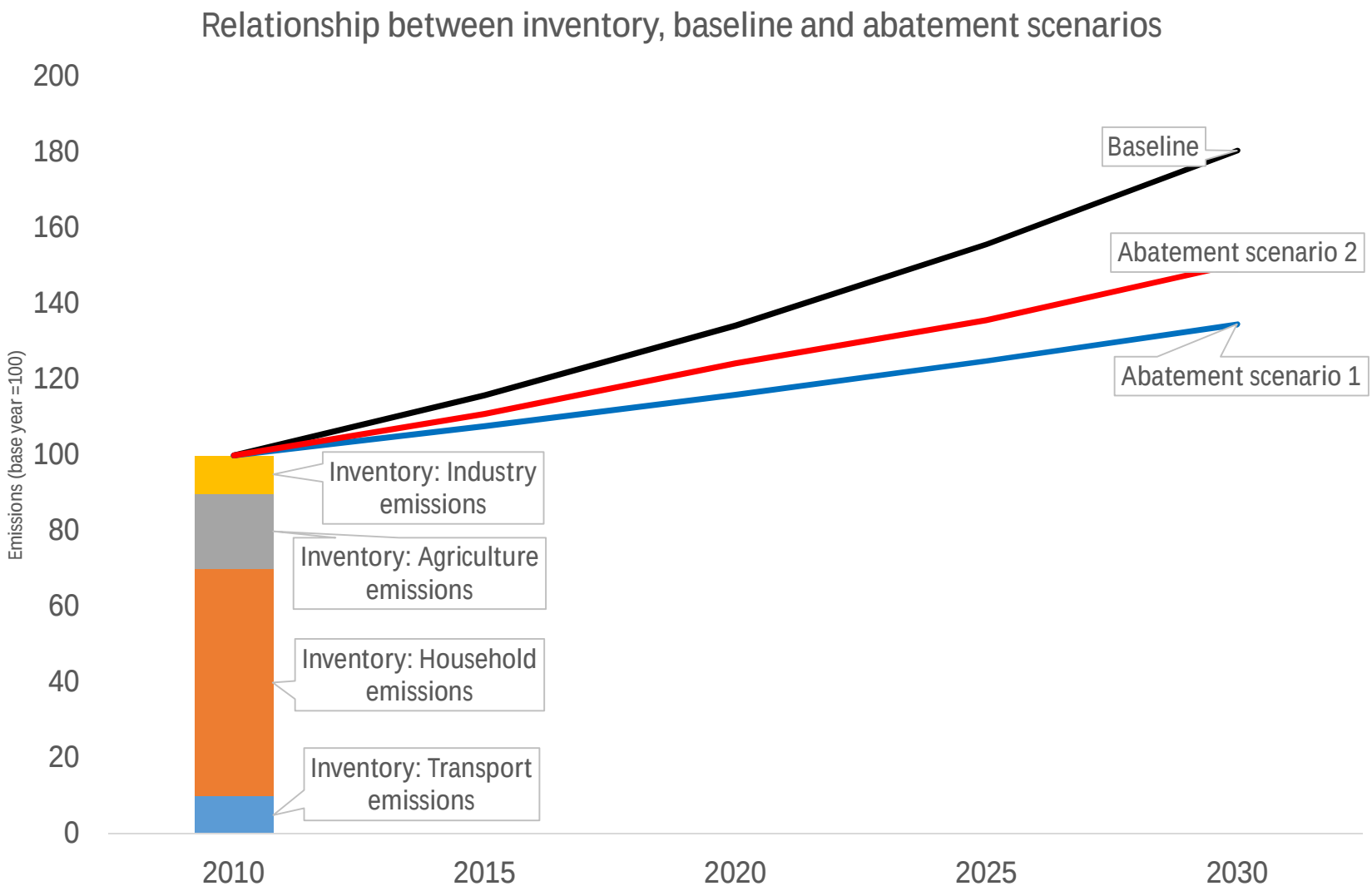
Improvement Cycle

Process:

1. Review & **prioritise previous recommendations** for improvement (if any)
2. Implement improvements where resources are available
3. Compile new estimates
4. Log **new ideas for improvement** that arise during compilation
5. Review new estimates
6. Fix errors & **log any arising improvements**
7. Submit inventory (**with improvement table in NIR**)
8. Respond to review questions & **log any arising improvements**
9. Take note of review recommendations and log and prioritise improvements
10. Go back to 1



Relationship between inventory, business as usual, and projections

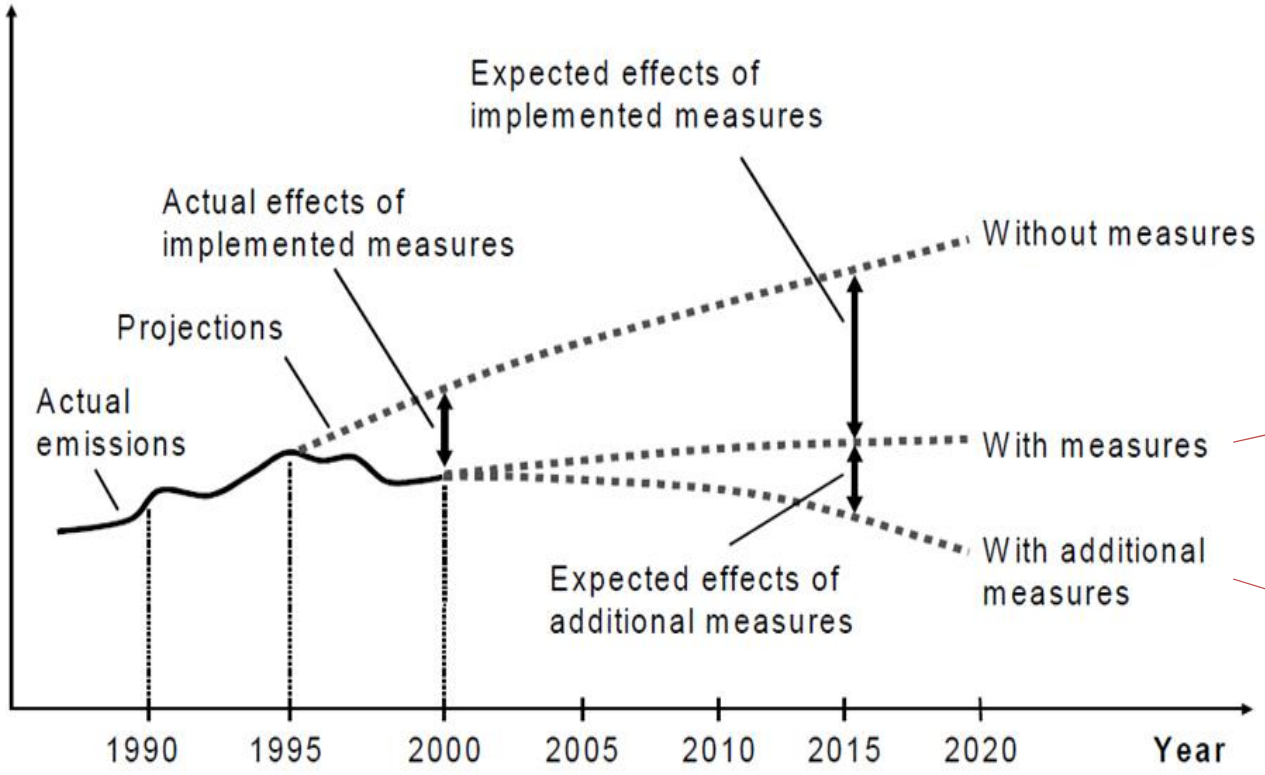


Emission Scenarios

- What do we mean by emissions scenarios?

IPCC – "Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties". ['*Emissions Scenarios', IPCC, 2000*]

UNFCCC guidance on projections



'Without measures' - excludes all policies and measures implemented, adopted or planned after the base year

'With (existing) measures' - encompasses currently implemented and adopted policies and measures.

"With additional measures" - also encompasses planned policies and measures but includes an estimate of the impact of additional mitigation measures

Implemented policies and measures	Adopted policies and measures	Planned policies and measures
• 1 or more of: • National legislation in force • One or more voluntary agreements have been established • Financial resources have been allocated • Human resources have been mobilized	• Official government decision has been made; and • Clear commitment to proceed with implementation	• Under discussion • Have a realistic chance of being adopted and implemented in future

Bottom-up versus top-down

Top-down:

Simple extrapolation model

Economic equilibrium model/CGE (e.g. WorldScan

Econometric models (E.g. E3MG)

Or hybrid (e.g. PRIMES, LEAP, POLES)

Bottom-up:

Dynamic optimisation (e.g. MARKAL)

Accounting (e.g. end-use sector models)

Simulation (elements of POLES, NEMS)

Top-down

- Characteristics
  - § System Integration
  - § Focus on macroeconomics, based on historical trends
  - § Focus on monetary units
  - § Can be very simple, e.g. Excel model of projected GDP and project carbon intensity of GDP, or forecasts of activity data and emissions factors (i.e. ‘projected’ inventory data)
  - § ……or very complicated, e.g. Dynamic general equilibrium models
- Strengths
  - § Can take account of ‘economic interlinkages’ (top-down optimisation models)
  - § Good for long-term analysis, as more stable due to econometric relationships
  - § Behaviour outside of energy sector endogenous to model
  - § Useful for financial instruments
- Weaknesses
  - § Limited technology detail
  - § But less informative in terms of the specific reasons for GHG trends
  - § Some top-down models can be somewhat ‘black-box’ (difficulty to validate)

Examples of top-down models

- PRIMES - a partial equilibrium model for the European Union energy markets. It is used for forecasting, scenario construction and policy impact analysis up to the year 2030. It simulates a market equilibrium for energy demand and supply within the European Union and it focuses on market-related mechanisms influencing the evolution of demand and supply.

- The Second Generation Model (SGM) is a computable general equilibrium model designed specifically to analyze issues related to energy, economy, and greenhouse gas emissions.

- Econometric model example http://camecon.com/EnergyEnvironment/EnergyEnvironmentGlobal/ModellingCapability/E3MG.aspx

Cement example – simple top-down forecasting

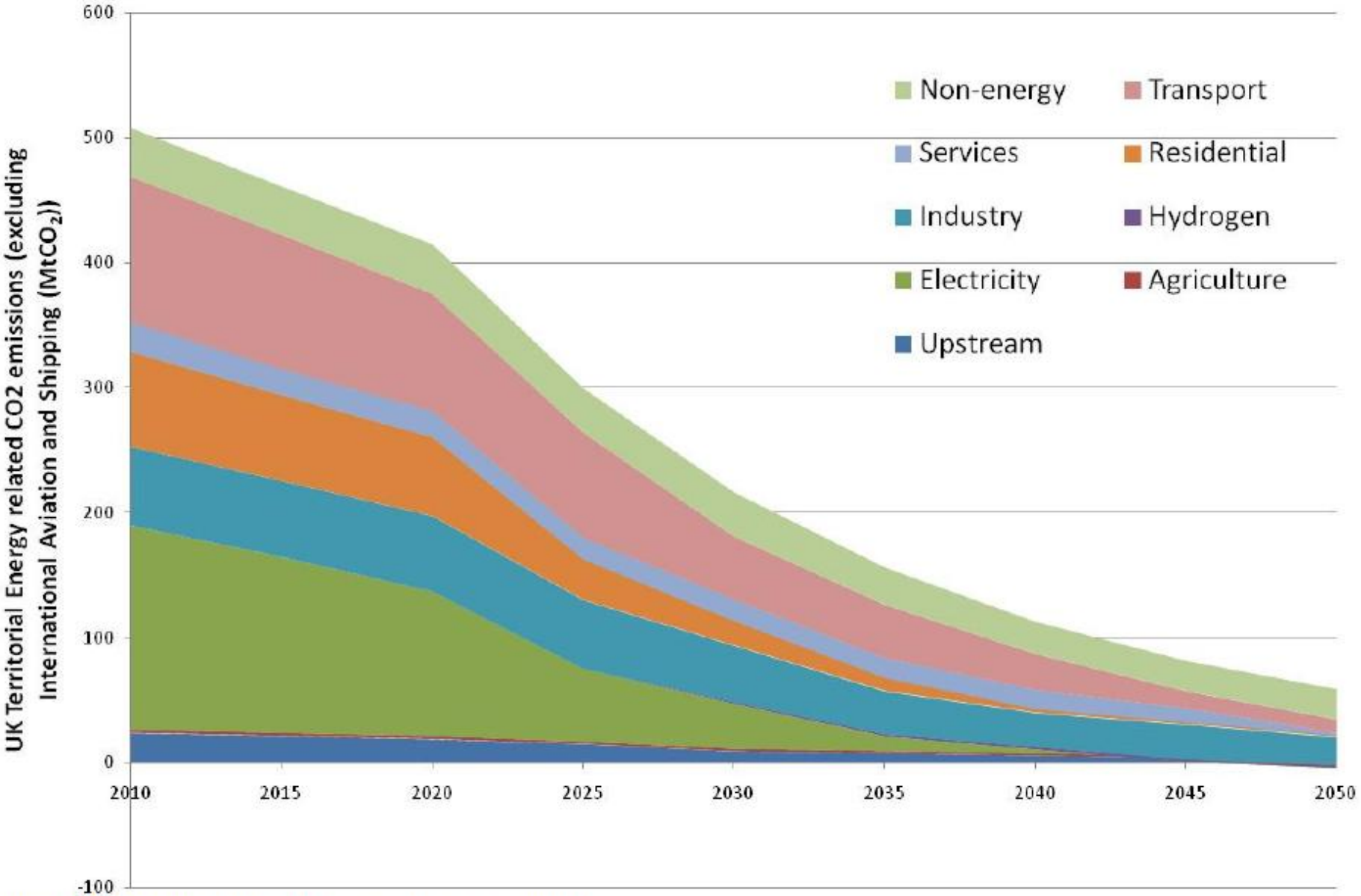
- Calculate current CO_2 emissions (including combustion and process emissions) emitted per tonne produced in various routes.
- Project forward production; base in short term on industry projections of production; in longer-term based on information from IEA report which gives projections of demand on per capita basics combined with projections of population and economic growth.
- Assume exports follow same trend as domestic demand i.e. production follows trend in domestic demand.
- For reference case use industry view about any trends in the relative proportions of production coming from the different production routes, e.g. relative proportion of EAF output increasing in response to growing availability of steel scrap.
- Use industry view about business as usual improvements in energy efficiency pertaining to the future, through incremental improvements and routine plant upgrades.
- From this data calculate total energy related GHG emissions and process related emissions

(Example taken from *IEA, 2009 Energy Technology Transitions for Industry, Strategies for the next Industrial Revolution)*

Bottom-up

- Characteristics
  - Technological detail
  - Macroeconomic variables exogenous to model
  - Focus on material units
  - Varies from partial equilibrium to simulation to emission reduction option database approach (GENESIS)
- Strengths
  - Rich in technology detail - easier to understand the reasons behind GHG trends
  - Decoupling economic growth from energy demand
  - Useful for technology oriented policy analysis, and other non-financial instruments
- Weaknesses
  - Data intensity – can be hard to obtain data
  - Lack of stability over longer time-frames

Example for a bottom-up model: Markal



Source: MARKAL modelling, AEA project for DECC (2011)

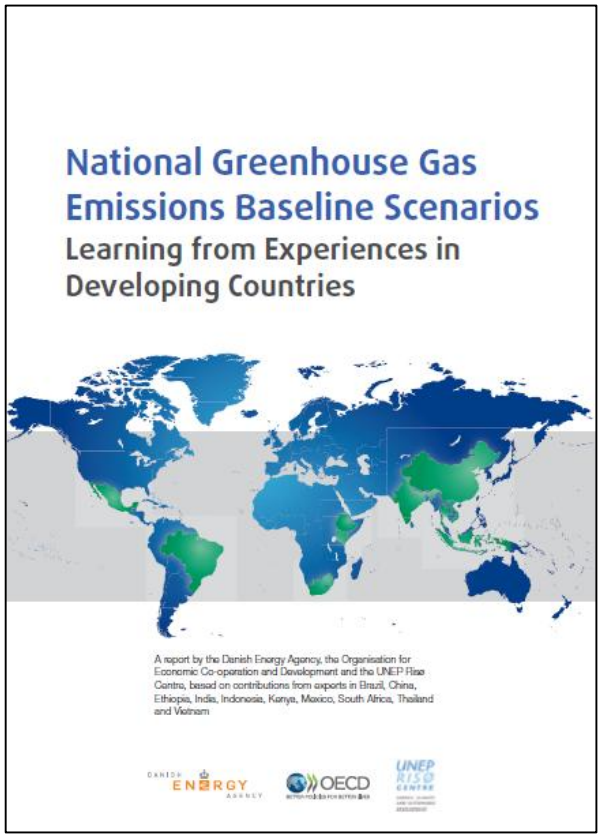
Key assumptions for projections

- GDP – could be from existing literature, or modelled
- Climatic patterns
- Population
- Technologies
- Costs
- Etc.

Useful guidance

National Greenhouse Gas Emissions Baseline Scenarios. Learning from Experiences in Developing Countries

- Successful policy-making hinges on robust analysis of expected future developments
- Scenarios describing plausible future trends in emissions help to achieve this
- The most important among these scenarios is the baseline or business-as-usual scenario, based on a robust baseline, which aims to characterise future emissions on the assumption that no new climate change policies will be adopted
- Preparing emissions scenarios involves making decisions and assumptions concerning many different underlying drivers of emissions, ranging from political factors to the type of modelling tools used
- Country examples



http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/national_greenhouse_gas_emissions_baseline_scenarios_-_web.pdf

The LEAP Model

Benefits of LEAP:

- Can be used to track energy consumption, production, resource extraction and non-energy greenhouse gas emissions in all sectors of an economy
- Listed on the UNFCCC website as a commonly used tool for developing mitigation plans
- Free to Governments and not for profit organisations in developing countries

Modelling approach: LEAP

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Inputs

Current emissions

Baseline projections

Scenario assumptions

Pre-processing

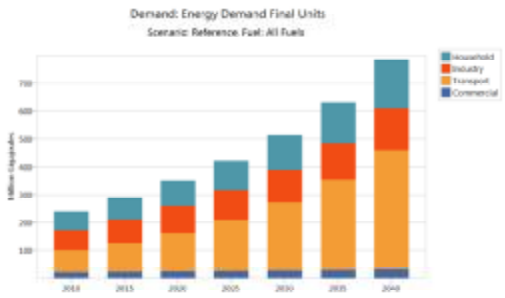
Abatement-agriculture

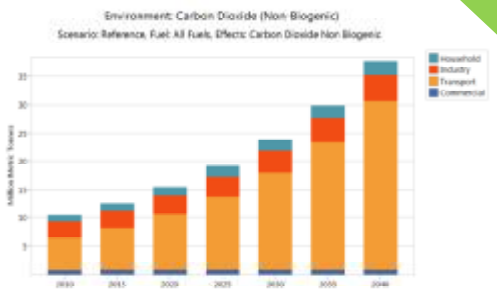
Abatement-industry

Main analysis

LEAP

Results



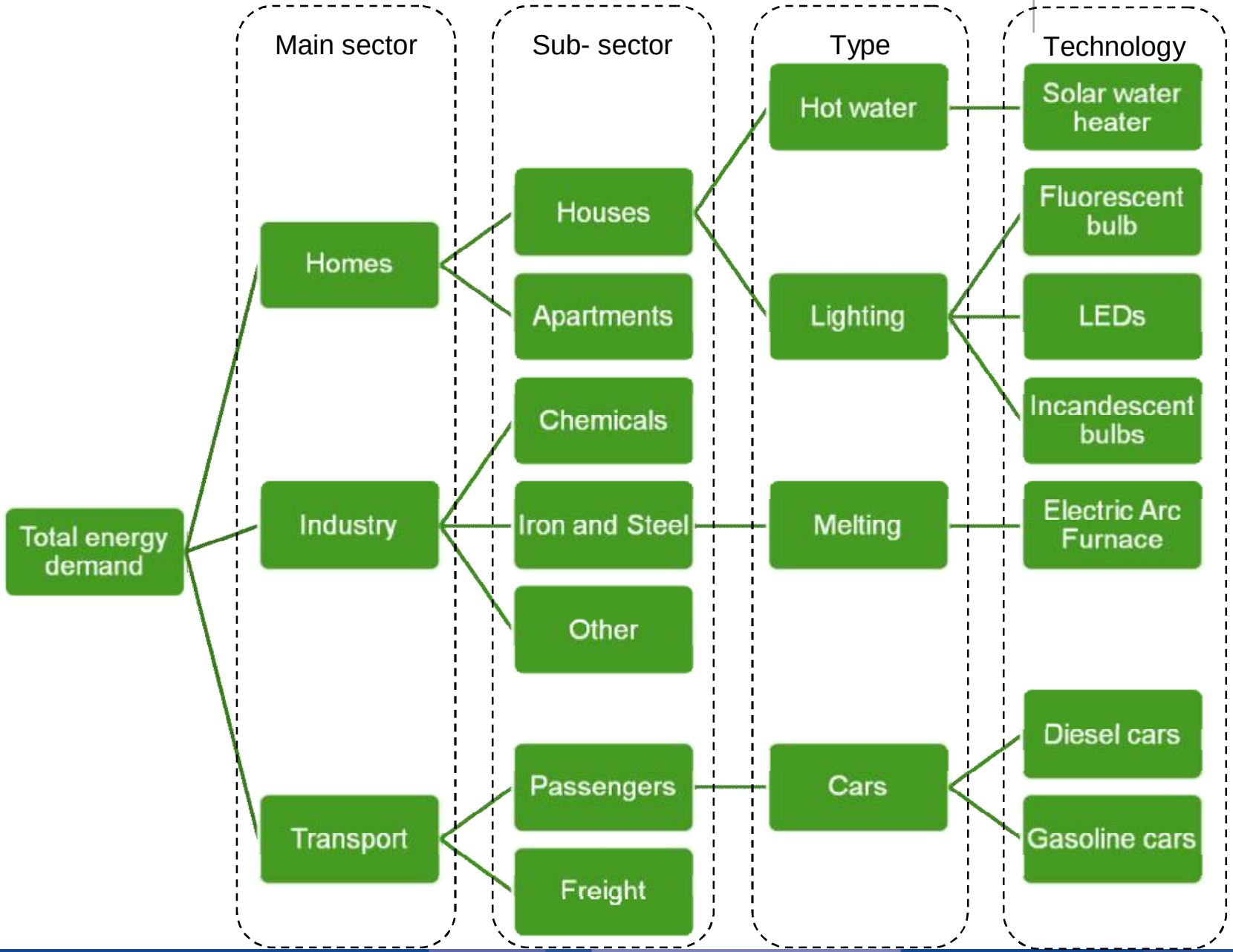


How to use LEAP

LEAP is “demand-driven”. Think about how much energy the country needs, and why it needs that energy:

- What are the main sectors in the country? Examples include homes, industry, transport.
- Do you need to split those sectors into sub-sectors? For example, split industry into iron and steel, chemicals and other. Split homes into apartments and houses.
- What are the main uses of energy in each sector? Examples include heating, passenger transport, freight, lighting.
- What is the technology that provides for each use? For example, a solar water heater provides hot water, a diesel engine provides passenger transport. Lighting can be from incandescent, fluorescent or LED bulbs

LEAP: Partial demand tree



Key messages

- Inventories and projections provide you with key information on low emission development strategies and a weath of other climate change related decisions
- Make a start! There is much guidance and simple approaches to build on over time.
- Ensure consistency between projection and GHG inventory data as far as possible
- Identify your key sources and the key factors for emission development over time (e.g. GDP, technology, population, etc.)
- Get cross-Government agreement on the way forward and establish sustainable structures
- Identify skills and resource gaps (and seek support to address those)
- Document what is done to retain knowledge
- Set up a system that enables a rolling programme of improvement
- Engage internationally and ask questions

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