NUCLEAR
REGULATORY AUTHORITY
OF THE SLOVAK REPUBLIC

Experience from MACCS Applications by the Slovak Regulator

J. Husarcek
UJD SR (NRA SR)

EMUG meeting, Brno, CZ

April 7 – 11, 2025

Highlights

- **Introduction**
  - UJD SR
  - Nuclear installations in Slovakia
- **Legal basis for radiological analyses**
- **MACCS applications**
- **Description of MACCS model and open questions**
- **Calculated results - example**
- **Conclusion - planned activities**

Introduction (1)

- **UJD SR – Central state administrative office responsible for state supervision of nuclear safety of nuclear facilities in Slovakia**
  - Core processes
    - Development of national decrees and guidelines
    - Review and assessment
    - Inspections and enforcement
    - Issuing decisions
    - Emergency planning and preparedness
    - Communication with public
  - ~130 employees including 87 nuclear safety inspectors
- **Division for safety analyses and technical support**
  - Performance of regulatory review calculations by means of computer codes
  - 1 person dealing with MACCS and radiological analyses

Introduction (2)

- **Bohunice site**
  - 2x WWER-440/V213 (V2 NPP) (in operation)
  - 2x WWER-440/V230 (V1 NPP) (in decommissioning)
  - 1x Heavy water moderated gas cooled reactor (A1 NPP) (in decommissioning)
  - Intermediate spent fuel storage (wet/dry)
  - Other installations for management of radioactive waste
  - New NPP (siting phase)

- **Mochovce site**
  - 3x WWER-440/V213 (in operation)
  - 1x WWER-440/V213 (in commissioning)
  - Other installations for management of radioactive waste

View on Bohunice NPP

source: website of SE, a. s.

View on Mochovce NPP

Legal basis for radiological analyses

- **Act on radiation protection (No. 87/2018 Coll. as amended)**
  - Requirements for radiological analyses
  - Conditions for the conductance of radiological analyses (e.g., dose conversion factors for workers/population, age dependent breathing rate, shielding factors)
  - Defined radiological limits (e.g., worker, student, population, situations)
  - Effective dose for various time periods (7 d, 1 y, 5 y, 50 y)
  - Effective dose for specific organs (eye lens, skin, whole-body) and age categories of the populations

- **UJD SR guidelines**
  - Specifications of provisions of generally binding legal documents (GBLD)
  - Description of methodology for radiological analyses (to some extent, for specific cases)
  - Some radiological limits

MACCS applications

- **Real use of MACCS at UJD SR since summer 2022**
- **External support for input deck development and code applications**
- **Regulatory review calculations in support of review and assessment of documentation submitted by license holder/applicant:**
  - Radiological analyses of selected DBAs/BDBAs/SA for radioactive releases into environment
  - Sensitivity calculations for selected parameters/models
  - No legislative requirements for PSA Level-3
- **MACCS models developed at UJD SR with external support and data set examples provided in MACCS delivery packages:**
  - Plant specific source term (radiological composition, mass, energy and timing of releases)
  - Data from national generally binding legal documents (e.g., breathing rate, conditions for radiological analyses)
  - Some input data are externally procured (i.e., hourly meteorological data for NPP sites in Slovakia)
  - Currently no collection of data on population, food and water ingestion, land use

MACCS model and open questions (1)

- **Currently used MACCS modules: ATMOS, EARLY and CHRONC (partially)**
  - **ATMOS** – calculations pertaining to atmospheric transport, dispersion and depositions while the material is in the atmosphere; downwind transport is modeled
  - **EARLY** – calculations pertaining to the emergency phase; the exposure pathways considered are cloud-shine, ground-shine, inhalation and resuspension inhalation
  - **CHRON**C – long-term phase of 1 year considered, the exposure pathways ground-shine, resuspension inhalation, food ingestion
  - **Food consumption basket updated to country specific conditions (COMIDA2 file)**
- **16 angular directions and 31 radial spatial elements (0.5–30.5 km) to be in line with protection zone, EPZ and experience from radiological analyses**
- **Site specific meteorological data**
  - Incomplete set of data (missing data)
  - Inconsistencies between the weather stability class (Pascquill) and wind speed, day/night time conditions

MACCS model and open questions (2)

- **Atmospheric dispersion coefficients (function of distance and weather stability category)**
  - Tadmor/Gur, Tadmor/Gur+Briggs a Eitimus
  - Karlsruhe-Julich system release
  - Differences in calculated dispersion – U.S.A. vs. EU
  - No consideration of country profile (changes in geodetic elevation)

- **Deposition (wet/dry) - considered 10 particle size groups**

- **60 – number of radioactive nuclides**
  - Core inventory calculated by – SCALE code (external support)

- **10 radionuclide groups (in correspondence to MELCOR code)**
  - Xe/Kr, Cs, Ba/Sr, I, Te, U, Mo, Ce, La and Cd

MACCS model and open questions (3)

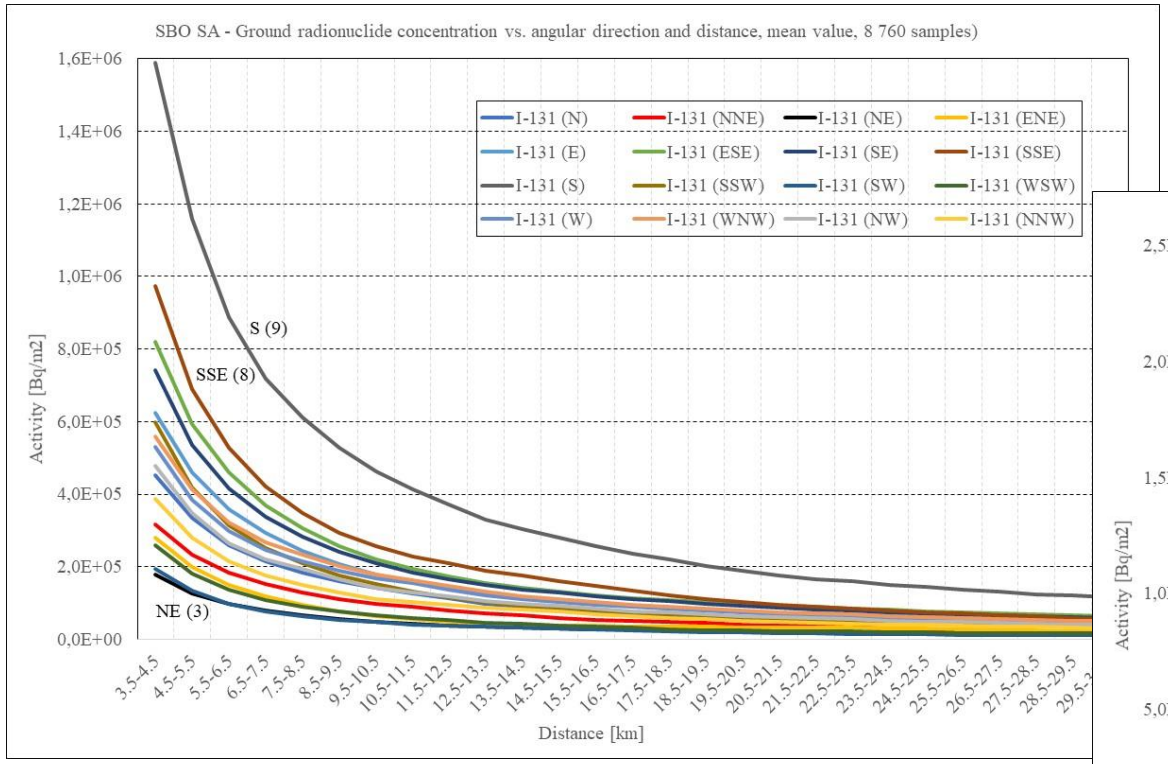
- **Core inventory a release fractions set up according to the analyzed scenario**
  - One source
  - Multi-plume release (from 20-30 up to several hundred plumes)
  - In variants – no wind shift/wind shift
- **Meteorological sampling data – random samples for each hour and day of the year 2023 (as a reference) or 2024**
- **DOSE conversion factors (DCF file FGR13DCF_v2)**
  - Conversion factors provided by Slovak national generally binding legal documents (Radiation protection act) differ from the factors used in MACCS sample problems (organs, radionuclides, values)
- **Shielding and exposure factors – considered normal activity, no evacuation, no sheltering, no iodine prophylaxis, one cohort**

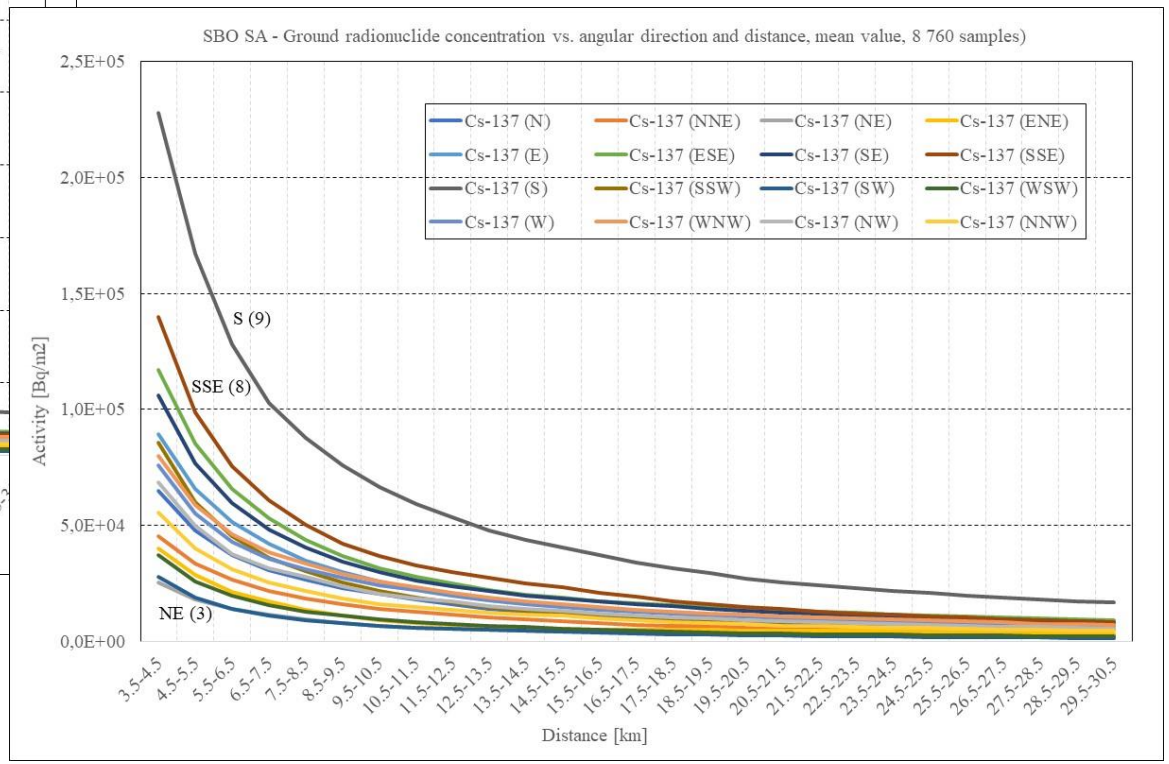
MACCS model and open questions (4)

- **LNT – Linear No Threshold model is used**

- **WinMACCS 4.2 runs from „command prompt“ window**
  - 1 code run takes from milliseconds to 20-30 minutes (depends on number of plumes and meteo)
  - Calculation of RN concentration in polar system tokes hours
- **Results from the modules ATMOS, EARLY, and CHRONC (usually without ingestion)**
- **Different exposure time (days, years)**
- **Calculated individual doses (Sv) for representative person**
- **Calculated activity (Bq) vs. distance (km)**
- **Calculated centerline dose (Sv) to 'L-ICRP60ED“ vs. distance, mean value, optionally other quantiles**
- **Calculated peak dose (Sv) to 'L-ICRP60ED“ vs. distance, mean value, optionally other quantiles**

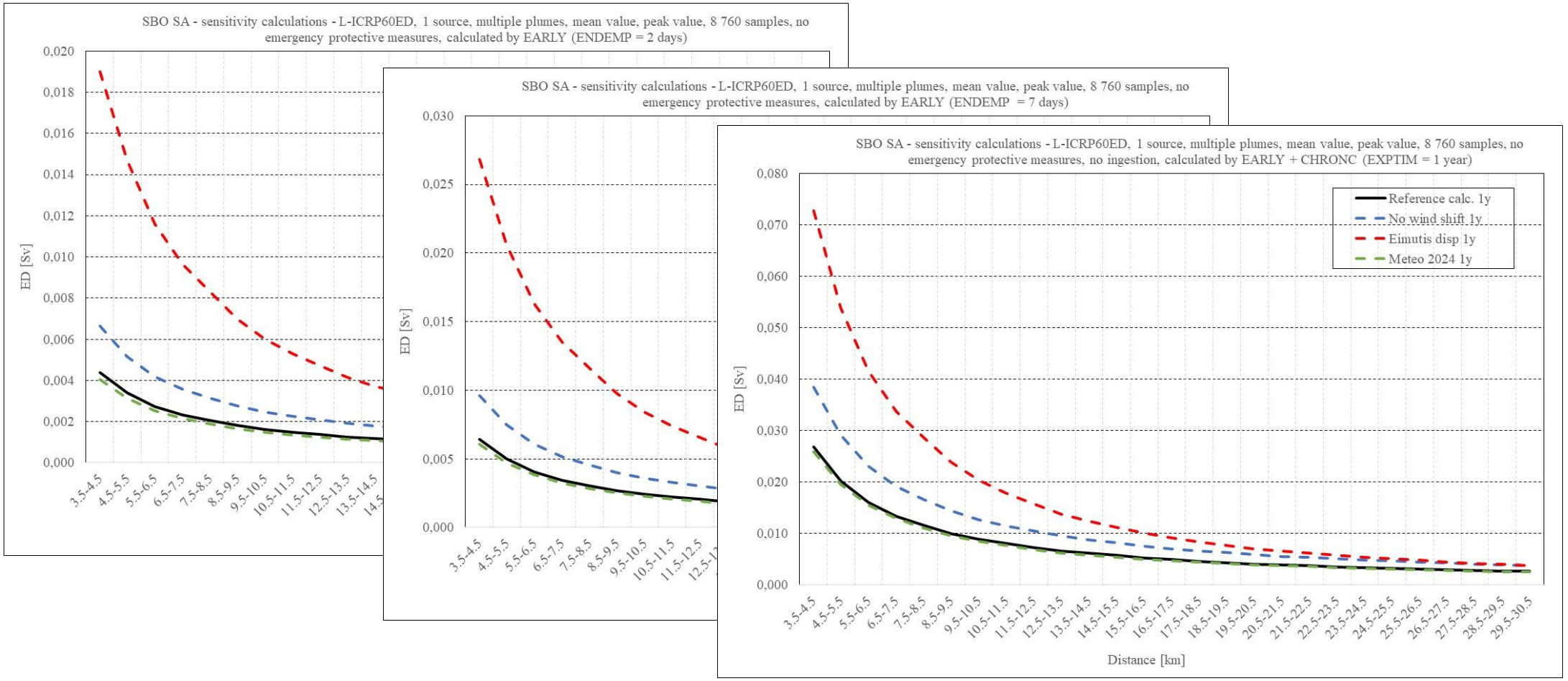
Calculated results – example (1)





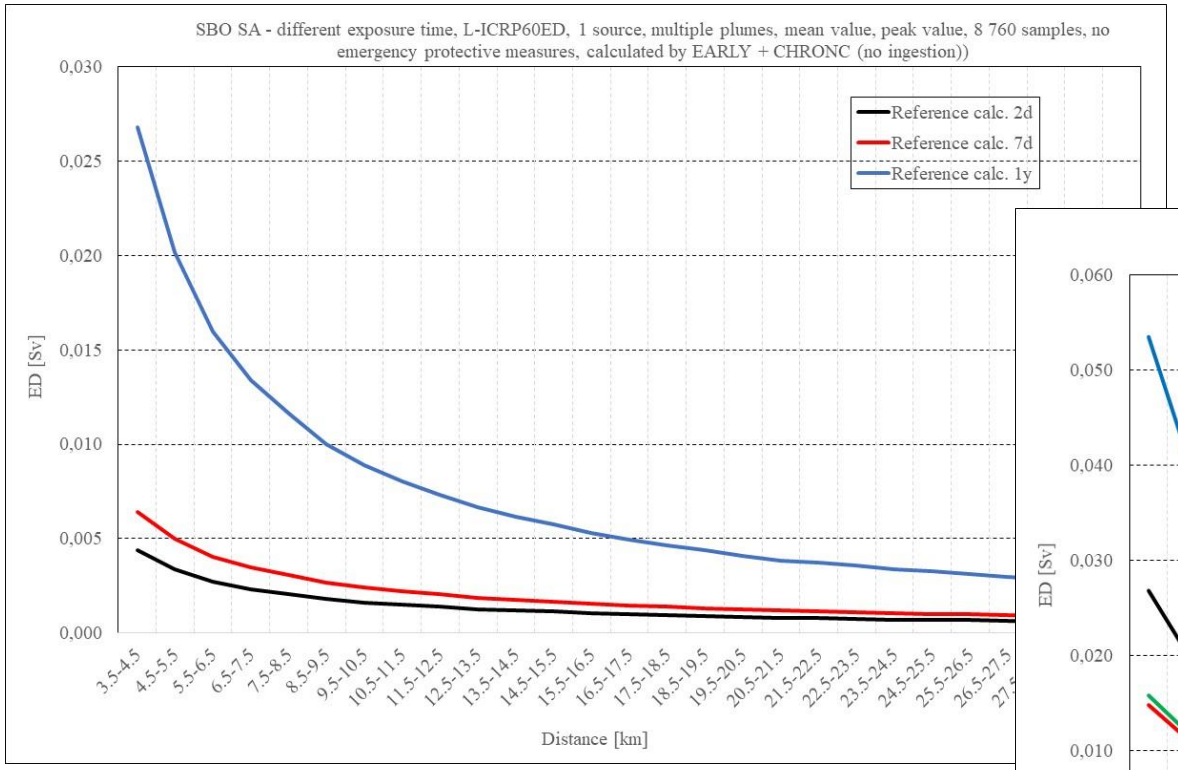
NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC

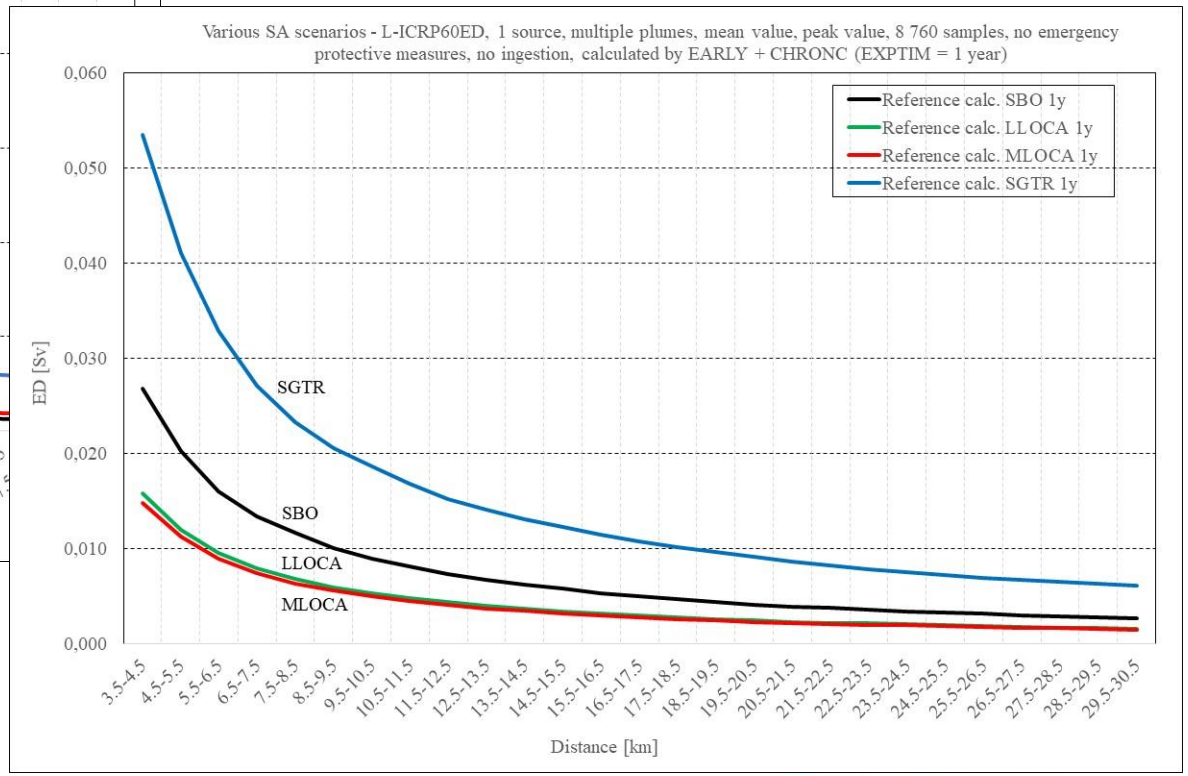
Calculated results – example (2)



NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC

Calculated results – example (3)





NUCLEAR REGULATORY AUTHORITY OF THE SLOVAK REPUBLIC

Conclusions and planned activities

- **Strong impact of atmospheric dispersion coefficients on calculated results**
- **Taking wind shift into account reduces peak ED values compared to no wind shift**
- **Very small impact of different meteo sets on peak ED values**
- **Lack of reliable socio-economic data for ED values from ingestion**
- **Difficulties in the evaluation of impact of available conversion factors on calculated results**
- **Getting experience from MACCS code, input model improvements and completion, RB verification calculations vs. utility submittals**

Thank you for your attention