IPS-CSC Forum

17 August 2010

"Enhancing Public Service Through Policy Automation"

Ballroom 3, Orchard Hotel

Institute of Policy Studies

Civil Service College Singapore

Energy Market Company

Lessons Learned from Automating the National Electricity Market of Singapore (NEMS) Settlement Market Rules

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SVP Market Operations and IT

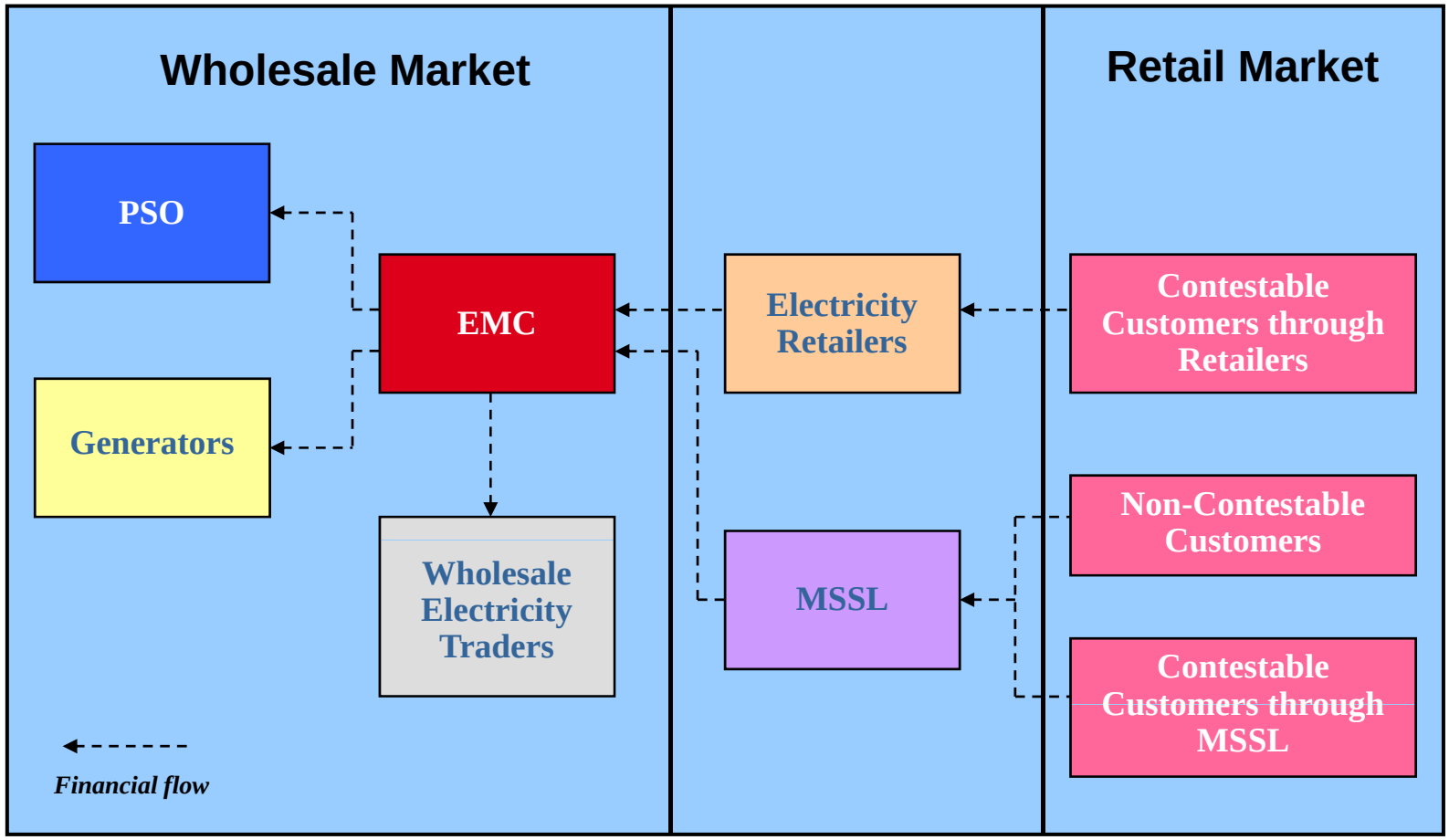
17 August 2010

Energy Market Company

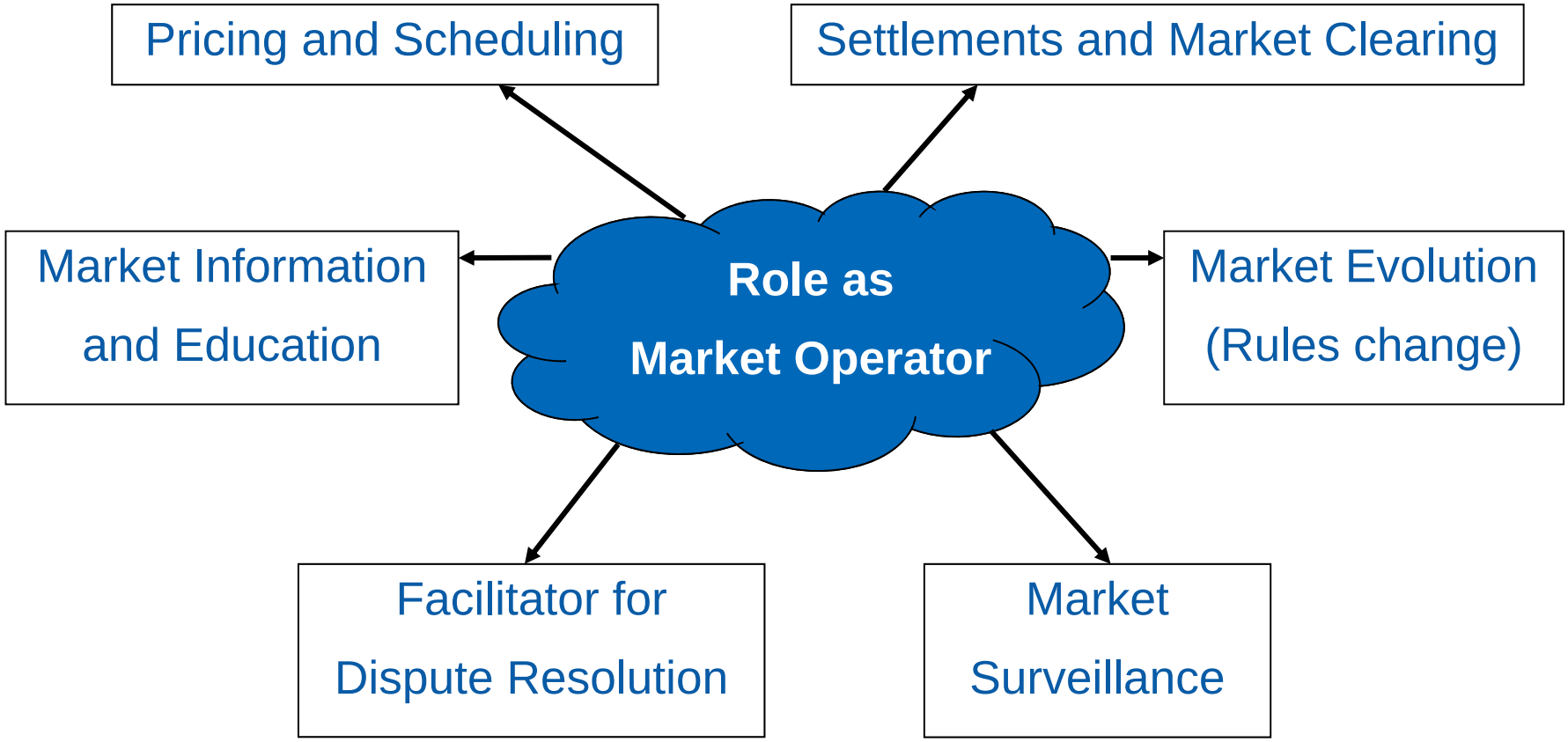
Agenda

- Energy Market Company
- Settlement Project Drivers
- Settlement Project Approach
- Settlement Project Outcome
- Settlement Project Challenges
- Conclusion

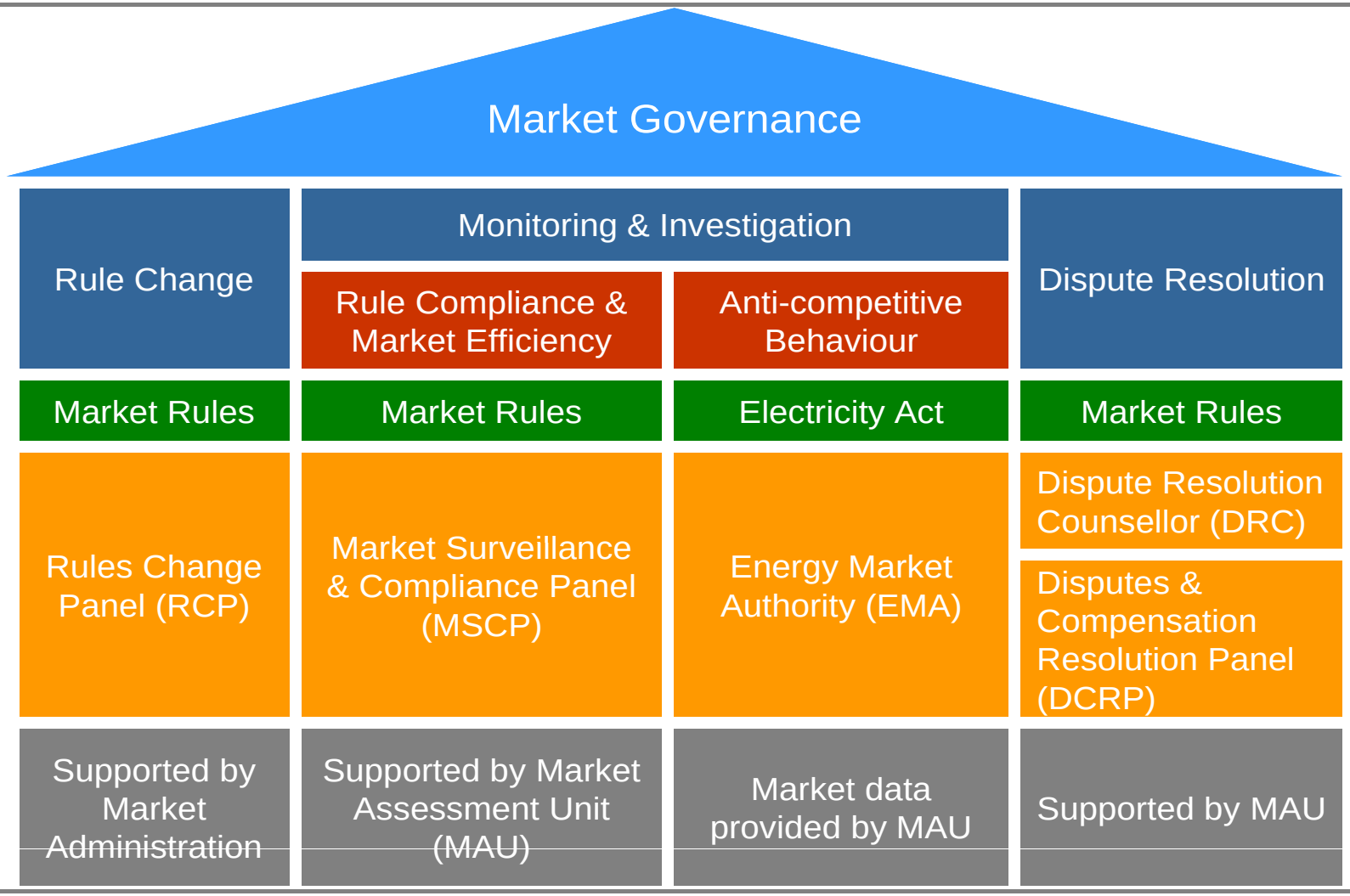
National Electricity Market of Singapore (NEMS)



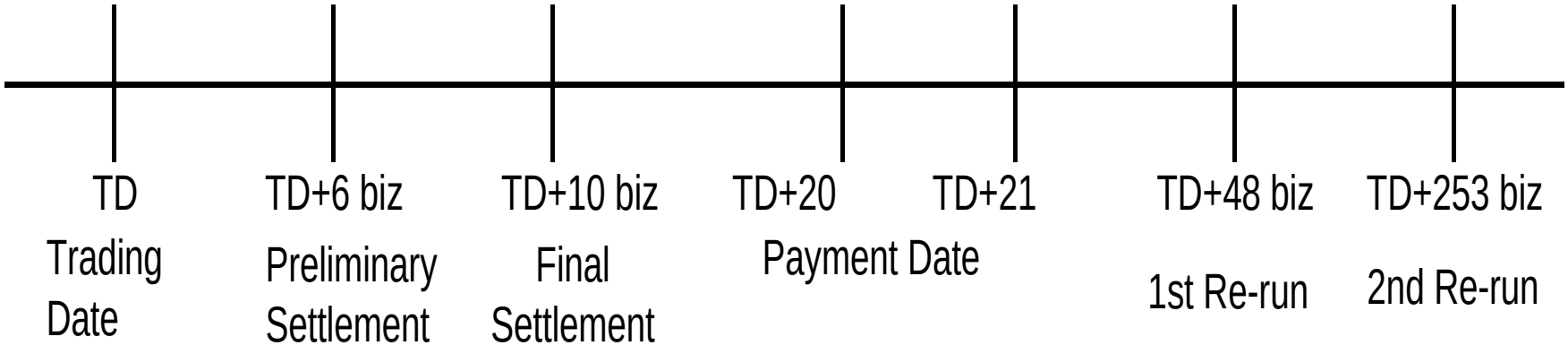
Energy Market Company



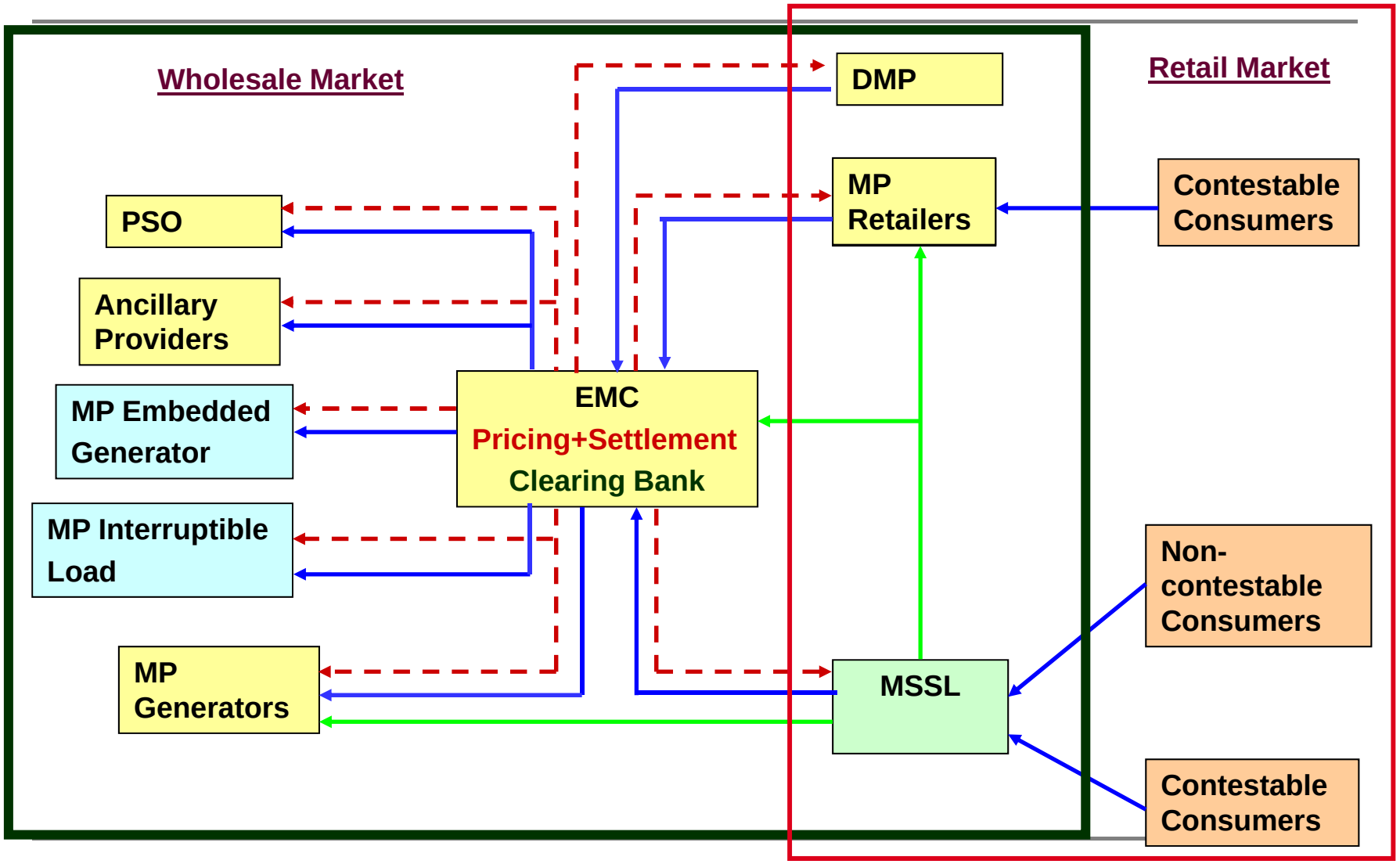
Energy Market Company



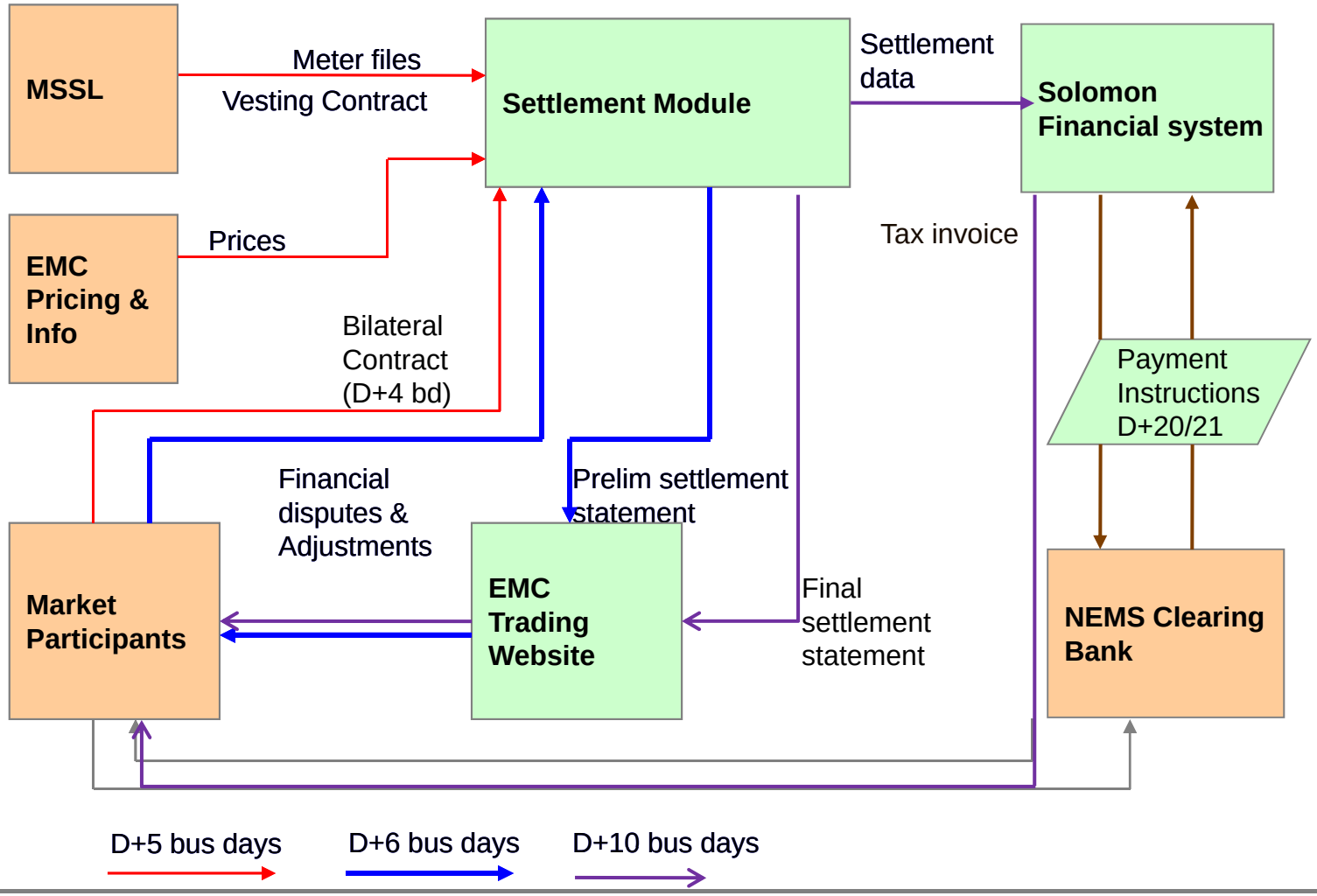
Singapore NEMS: Settlement cycle



Centralised Settlement



Settlement Process



Settlement Process & Market Rules

Settlement Module

1 INTRODUCTORY RULES

1.1 PURPOSE

Explanatory Note: For generality, these rules allow for more than one MSSL – although some MSSL functions, most notably the reconciliation of metering data, the allocation of losses, etc., are natural monopoly functions that cannot realistically be decentralised among multiple MS

1.1.1 This chapter sets out the respective rights
the *PSO*, *market participants* and *market s*
determining, billing for and paying financ
transactions in the *wholesale electricity m*
provisions of the *market rules* and *applica*
ting to the

4.4.7.2 The *EMC* shall determine an index size function S(z) such that:

S(z) = injection *energy* quantity at the *MNN* ranked at index position z under section 4.4.7.1

$S(z) \leq S(z+1)$

4.4.7.3 The *EMC* shall determine T(z) such that:

$$T(z) = S(z)/\sum_{j=1}^{Z} S(j)$$

Z = total number of *MNNs* for *settlement account* sa
excluding *MNNs* at which the injection *energy*

3.1 NET ENERGY SETTLEMENT CREDITS

3.1.1 The *EMC* shall determine the generation *energy settlement* credit (GESC) applicable to each *settlement account* in each *settlement interval* in accordance with the following formula:

$$GESC_h^a = \Sigma_{m(a)} MEP_h^{m(a)} \times IEQ_h^{m(a)}$$

where:

a = a *settlement account*

h = a *settlement interval*

$\Sigma_{m(a)}$ = sum over all *GRFs* m(a) and *GSFs* m(a) associated with *settlement account* a

3.1.2 The *EMC* shall determine the *load energy settlement* debit (LESD) applicable to each *settlement account* for each *settlement interval* in accordance with the following formula:

$$LESD_h^a = USEP_h \times WEQ_h^a$$

Settlement Project Drivers

Maturing market required more efficient and flexible settlement system to meet the NEMS' future needs. Key business objectives:

- Increase the assurance that system provides compliance with critical settlement rules
- Better manage the end-to-end settlement processes
- Implement more flexible, scalable and robust NEMS system architecture
- Increase operational efficiency through automating manual processes to minimize human intervention/time involved

Settlement Project Approach

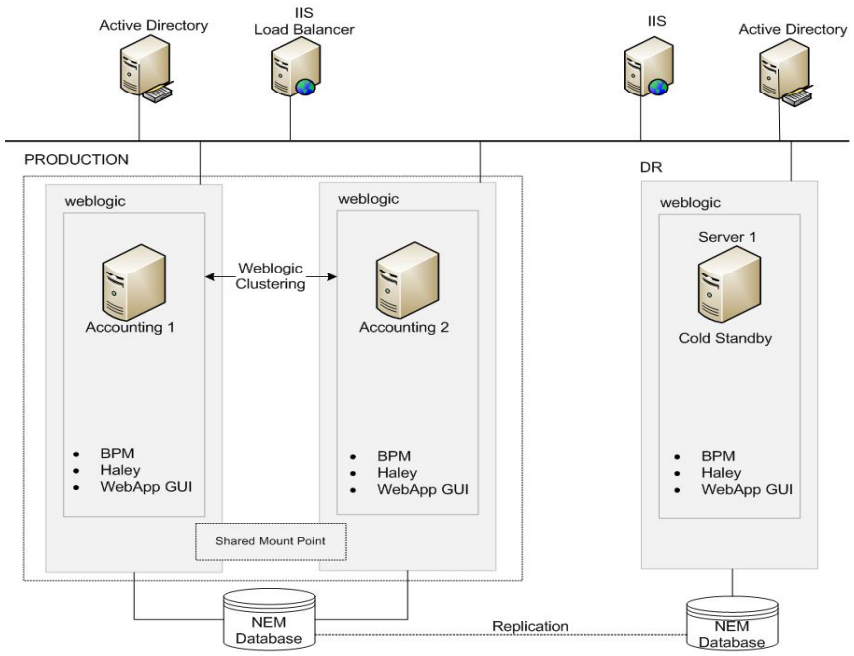
- Outside-in approach to Enterprise Architecture – Mapping the market rules to business services
- Business process management
- Business rules enforcement
- Global product and local customization implementation strategy

Settlement Project Outcome

- Business process alignment - team now has greater visibility on the actual system's execution
- Business agility - business logic and calculation are external from system instead of coded into system logic
- Business productivity gain - increase operational efficiency through automating manual processes
- Cost saving - proven commercial tools with customization from a local technology vendor

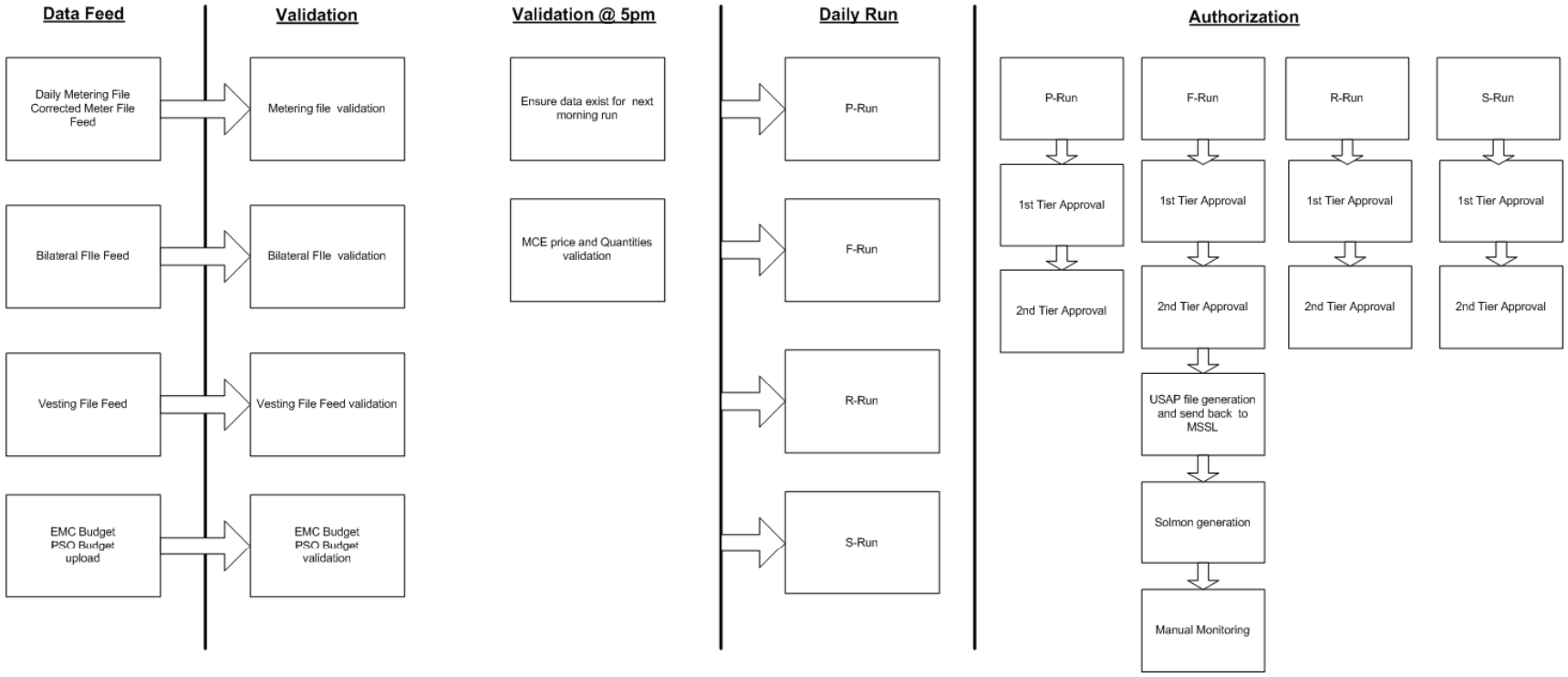
Settlement Project Outcome

- **Decoupled the market rules and business logic from the NEMS database**
  - Reduced the dependency on database
  - Database resources available for other critical processing



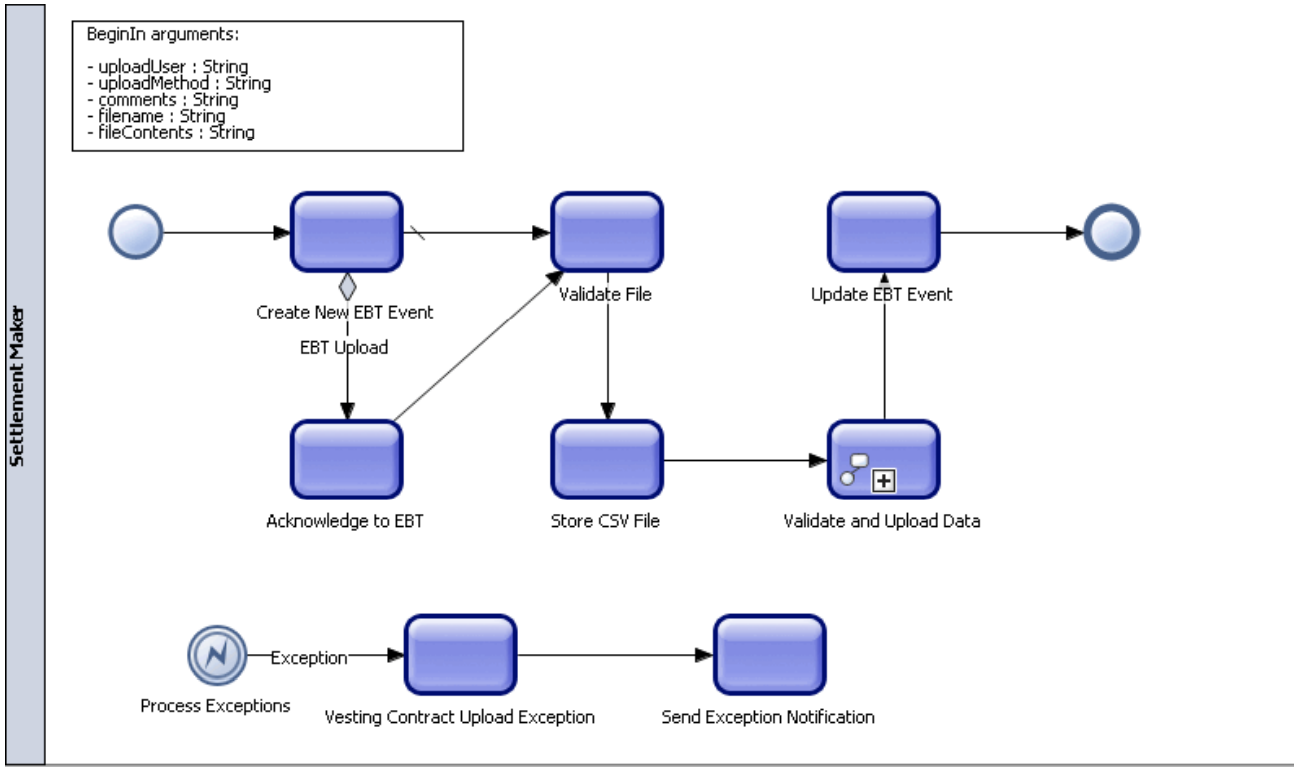
Settlement Project Outcome

- **Externalized and modeled the business requirements into workflow**
  - Visibility and ease of maintenance



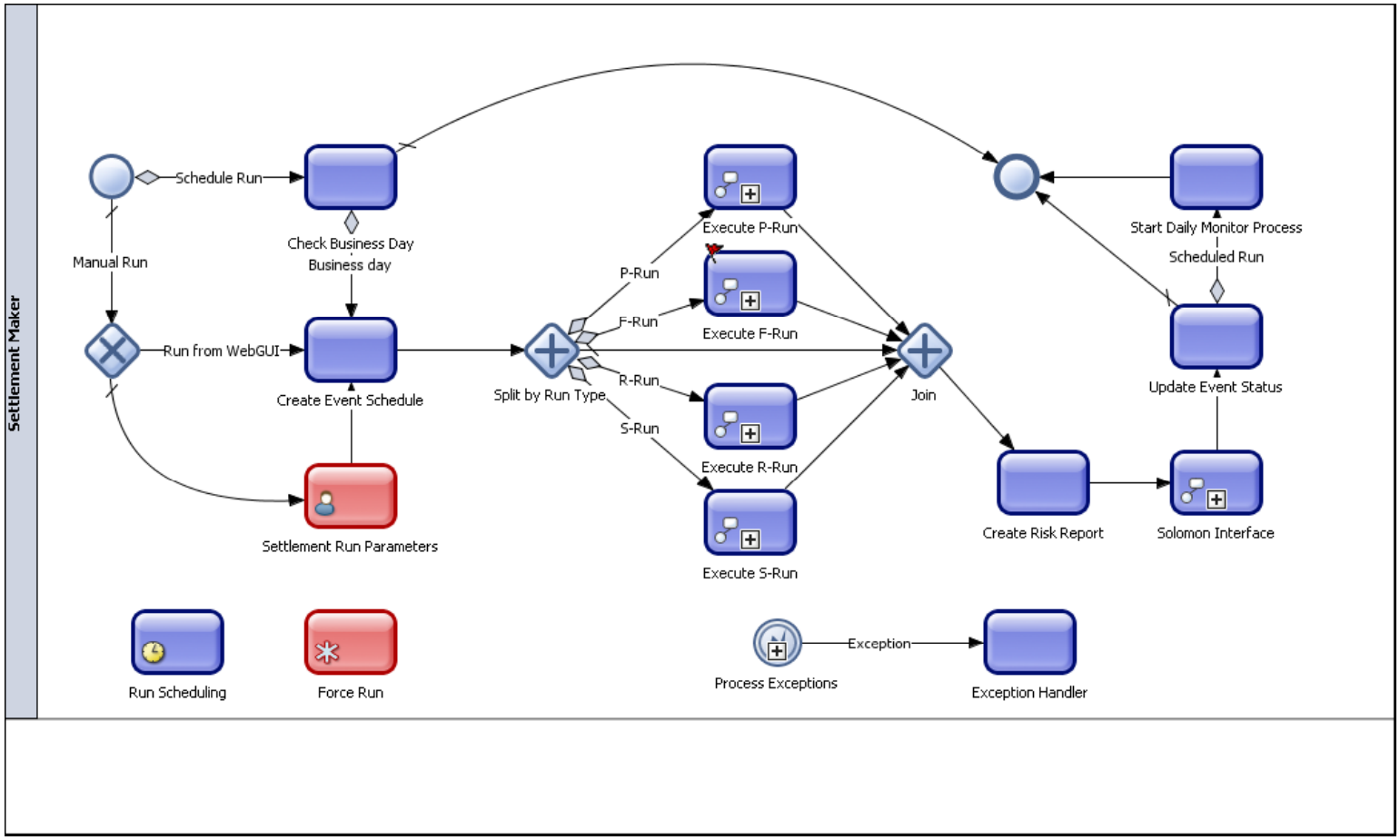
Settlement Project Outcome

- **Vesting File Validation and Processing**



Settlement Project Outcome

- **F-Run Flow**



Settlement Project Outcome

- **Settlement calculation is based on the Market Rule**
  - Example of Calculating Meter Error Adjustment

B.4.2 The *metering error* adjustments for each affected *settlement account* for each *settlement interval* shall be determined as follows:

Generation *metering error* adjustment for *energy* (GMEE) and generation *metering error* adjustment for fees (GMEF) shall be determined as follows:

$$GMEE_h^a = \sum_{m(a)} (MEP_h^{m(a)} \times \Delta IEQ_h^{m(a)})$$

$$GMEF_h^a - \sum_{m(a)} (PSOA_h + EMCA_h) \times \Delta IEQ_h^{m(a)}$$

Load metering error adjustment (LMEA) shall be determined as follows:

$$LMEA_h^a = [(USEP_h + AFP_h + HEUC_h) \times \Delta WEQ_h^a] + [(MEUC_h + PSOA_h + EMCA_h) \times \Delta WCQ_h^a]$$

Net *metering error* adjustment (NMEA) shall be determined as follows:

$$NMEA_h^a = GMEE_h^a - GMEF_h^a - LMEA_h^a$$

Where:

(i) $MEP_h^{m(a)}$, $USEP_h$, AFP_h, $HEUC_h$, $MEUC_h$, $PSOA_h$ and $EMCA_h$ are rates computed in the *final settlement statement* for *trading day* T

Settlement Project Outcome

- **Mapping the rules to technical implementation – Old Way**

B.4.2 The *metering error* adjustments for each affected *settlement account* for each *settlement interval* shall be determined as follows:

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```
DEFINE rep_filename = 'NMEA'
DEFINE rep_extension = ".csv"
DEFINE sep = "_"

SPOOL &rep_filename&sep&p_run_type&rep_extension

select 'Sett ID,Sett Date(Prelim),Sett Date,Period,GMEE,GMEF,LMEE,LMEF,NMEA'
  from dual;

select trim(external_id)||','||
       trim(p_sett_date)||','||
       trim(settlement_date)||','||
       trim(to_char(period))||','||
       trim(gmee)||','||
       trim(gmef)||','||
       trim(lmee)||','||
       trim(lmef)||','||
       trim(nmea) as nmea_csv_row
  from ( select sac.external_id,
                to_date('&p_date','dd-Mon-rr')                    as p_sett_date,
                rstr.Settlement_date,
                period,
                sum(decode(srt.name, 'GMEE', 1 ,0)  * nsr.calculation_result) as GMEE, -- 1.2
                sum(decode(srt.name, 'GMEF', -1 ,0) * nsr.calculation_result) as GMEF, -- 1.2
                sum(decode(srt.name, 'LMEE', -1, 0) * nsr.calculation_result) as LMEE, -- 1.2
                sum(decode(srt.name, 'LMEF', -1, 0) * nsr.calculation_result) as LMEF, -- 1.2
                sum(decode(srt.name, 'LMEE', -1,
                                     'LMEF', -1,
                                     'GMEE',  1,
                                     'GMEF', -1,
                                     0 ) * nsr.calculation_result   )     as NMEA
           from nem_settlement_result_types srt,
                nem_settlement_results      nsr,
                nem_settlement_accounts     sac,
                nem_settlement_runs         rstr,
                -- subquery finds all settlement reruns that were included
                -- in the latest prelim/final run
                ( select /*+ no_merge */
                         inc.rerun_str_id
                    from nem_settlement_runs       str,
                         nem_settlement_rerun_incs inc
                   where str.settlement_date = to_date('&p_date','dd-Mon-rr')
                     and str.run_type        = '&p_run_type'
                     and str.id              = inc.str_id
                     and str.run_date        = ( SELECT MAX(sstr.run_date) max_date
                                                   FROM nem_settlement_runs sstr
                                                  WHERE sstr.settlement_date = TO_DATE('&p_date','DD-Mon-RR')
                                                    AND sstr.run_type        = '&p_run_type' ) ) mrun
          where nsr.srt_id      = srt.id
            and nsr.srt_version = srt.version
            and nsr.sac_id      = sac.id
            and nsr.sac_version = sac.version
            and sac.external_id not in ('EMC ADJ_A','EMC CLR_A','EMC REC_A','EMC RES_A','INTERTIE','PWR GRID_T','PWR SYS_O')
            and srt.name       in ('LMEE','LMEF','GMEF','GMEE')
            and rstr.id         = mrun.rerun_str_id
            and nsr.str_id      = mrun.rerun_str_id
       group by sac.external_id,
                to_date('&p_date','dd-Mon-RR'),
                rstr.Settlement_date,
                Period
     )
order by   p_sett_date,
           Settlement_date,
           external_id,
           Period;

SPOOL OFF
```

Settlement Project Outcome

- **Mapping the rules to technical implementation – Old way**

B.4.2 The *metering error* adjustments for each affected *settlement account* for each *settlement interval* shall be determined as follows:

Generation *metering error* adjustment for *energy* (GMEE) and generation *metering error* adjustment for fees (GMEF) shall be determined as follows:

$$GMEE_h^a = \sum_{m(a)} (MEP_h^{m(a)} \times \Delta IEQ_h^{m(a)})$$

$$GMEF_h^a = \sum_{m(a)} (PSOA_h + EMCA_h) \times \Delta IEQ_h^{m(a)}$$

Load metering error adjustment (LMEA) shall be determined as follows:

$$LMEA_h^a = [(USEP_h + AFP_h + HEUC_h) \times \Delta WEQ_h^a] + [(MEUC_h + PSOA_h + EMCA_h) \times \Delta WCQ_h^a]$$

Net *metering error* adjustment (NMEA) shall be determined as follows:

$$NMEA_h^a = GMEE_h^a - GMEF_h^a - LMEA_h^a$$

Where:

(i) $MEP_h^{m(a)}$, $USEP_h$, AFP_h, $HEUC_h$, $MEUC_h$, $PSOA_h$ and $EMCA_h$ are rates computed in the *final settlement statement* for *trading day* T

```
DEFINE rep_filename = "LMEA"
DEFINE rep_extension = ".csv"
DEFINE sep = "_"

SPOOL &rep_filename&sep&p_run_type&rep_extension

select 'Sett ID,Settlement Date,Period,dWEQ,dWCQ,USEP,AFP,HEUC,MEUC,PSO Admin,EMC Admin,LMEE,LMEF,LMEA' --1.2 added WCQ
  from dual;

select trim(sett_id)||','||
       trim(settlement_date)||','||
       trim(to_char(period))||','||
       trim(dweq)||','||
       trim(dwcq)||','|| -- 1.2 Added new column
       trim(usep)||','||
       trim(afp)||','||
       trim(heuc)||','||
       trim(meuc)||','||
       trim(pso_admin)||','||
       trim(emc_admin)||','||
       trim(lmee * -1)||','|| -- 1.4 Added the debit indicator
       trim(lmef * -1)||','|| -- 1.4 Added the debit indicator
       trim(to_char(to_number(lmee) + to_number(lmef),'99999999999.99') * -1 ) --1.2 lmea is calculated here instead of in the sub q
debit indicator
  from -- Here we calculate all of the prices and quanities required to calculate the LMEA calculation
       ( select dweq.external_id                                    as sett_id,
                to_char(dweq.settlement_date,'dd-Mon-yy')           as settlement_date,
                dweq.period                                         as period,
                to_char(dweq.delta_weq)                             as dWEQ,
                to_char(dwcq.delta_wcq)                             as dWCQ, --1.2 Added new column
                to_char(dweq.usep,'99999999999.99')                 as USEP,
                to_char(dweq.afp,'99999999999.99')                  as AFP,
                to_char(dweq.heuc,'99999999999.99')                 as HEUC,
                to_char(dweq.meuc,'99999999999.99')                 as MEUC,
                to_char(fee.psoadmin_mw_charge,'99.999999')         as PSO_ADMIN,
                to_char(fee.emcadmin_mw_charge,'99.999999')         as EMC_ADMIN,
                ( case
                  when dweq.settlement_date >= nem$util.get_sp_dt('PN_EFFECTIVE_DATE') then --1.5 PN effective date check is correct
                    to_char(((dweq.usep+dweq.afp+dweq.heuc) * dweq.delta_weq) + ( dweq.meuc * dwcq.delta_wcq),'99999999999.99')
                  else
                    to_char(((dweq.usep+dweq.afp+dweq.heuc+dweq.meuc) * dweq.delta_weq),'99999999999.99')
                  end
                ) LMEE, --1.2 Modified to include WCQ
                ( case
                  when dweq.settlement_date >= nem$util.get_sp_dt('PN_EFFECTIVE_DATE') then --1.5 PN effective date check is correct
                    to_char((fee.psoadmin_mw_charge + fee.emcadmin_mw_charge ) * dwcq.delta_wcq,'99999999999.99')
                  else
                    to_char((fee.psoadmin_mw_charge + fee.emcadmin_mw_charge ) * dweq.delta_weq,'99999999999.99')
                  end
                ) LMEF --1.2 Modified to include WCQ
           from -- 1.2 This sub query is used to calculate the WCQ value which is required for embedded gen calcs
                (  select nvl(rstq.quantity,0) - nvl(pstq.quantity,0) as delta_wcq,
                          rstq.settlement_date,
                          rstq.period,
                          sac.id as sac_id
                     from nem_settlement_run_status_v  srs,
                          nem_settlement_quantities    pstq, -- previous data
                          nem_settlement_quantities    partition ( &1 ) rstq, -- rerun data
                          nem_settlement_accounts      sac
                    where srs.run_type          = 'F'
                      and srs.authorised        = 'A'
                      and srs.status            = 'F'
                      and srs.settlement_date   = TO_DATE('&p_date','DD-Mon-RR') -- modified the RHS to filter the rows before join.
                      and rstq.quantity_type    = 'WCQ'
                      and rstq.settlement_date  = TO_DATE('&p_date','DD-Mon-RR')
                      and rstq.sac_id           = sac.id
                      and rstq.sac_version      = sac.version
                      and rstq.version          = ( SELECT MAX(TO_NUMBER(version))
                                                      FROM pav_packages pkg,
                                                           pav_package_types pkt
```

Settlement Project Outcome

- **Mapping the rules to technical implementation – New way**

Normal	
Haley - Heading 3	**B.4.2.4 Net *Metering Error* Adjustment (NMEA)**
Normal	
Normal	Net *metering error* adjustment (NMEA) shall be determined asfollows:
Normal	$NMEA_{a,h}$ = $GMEE_{a,h}$ - $GMEF_{a,h}$ - $LMEA_{a,h}$
Normal	Where:
Normal	(i) $MEP_{a,h}^{m(a)}$, $USEP_h$, AFP_h, $HEUC_h$, $MEUC_h$, $PSOA_h$ and $EMCA_h$ are rates computed in the *final settlement statement* for *trading day* T
Normal	(ii) a = a *settlement account*
Normal	(iii) h = a *settlement interval*
Normal	(iv) $MEP_{a,h}^{m(a)}$ = *MEP* for *settlement interval* h for a *market network node* associated with *settlement account* a.
Normal	(v) $\Sigma_{m(a)}$ = sum over all *GRFs* m(a) and *GSFs* m(a) associated with *settlement account* a.
Normal	(vi) $\Delta IEQ_{a,h}^{m(a)}$, $\Delta WEQ_{a,h}$ and $\Delta WCQ_{a,h}$ are computed based on B.3.1 above.
Normal	(vii) $PSOA_h$ = the rate of *PSO*'s administrative costs to be recovered from a *settlement account* for a *settlement interval* under section 4.2 of this Chapter.
Normal	(viii) $EMCA_h$ = the rate of *EMC*'s administrative costs to be recovered from a *settlement account* for a *settlement interval* under section 4.2 of this Chapter.
Normal	
Normal	
Haley - conclusion	**the interval's NMEA = the interval's GMEE – the interval's GMEF – the interval's LMEE – the interval's LMEF**
Normal	

Settlement Project Outcome

- **Mapping the rules to technical implementation – New way**

Haley - Heading 3
Normal
Normal

Normal
Normal
Normal
Normal
Haley - conclusion

Normal
Normal
Normal
Haley - conclusion

Normal
Normal

B.4.2.3 *Load Metering Error* Adjustment (LMEA)

Load metering error adjustment (LMEA) shall be determined as follows:

$LMEA_s = [(USEP_s + AFP_s + HEUC_s) \times \Delta WEQ_s] +$
$[(MEUC_s + PSOA_s + EMCA_s) \times \Delta WCQ_s]$

the interval's LMEE = Round((the interval's imported USEP + the interval's imported AFP + the interval's imported HEUC) * the interval's change in WEQ + the interval's imported MEUC * the interval's change in WCQ, 2)

the interval's LMEF = Round((the interval's imported PSOA + the interval's imported EMCA) * the interval's change in WCQ, 2)

Settlement Project Milestones

The major milestones of the Settlement project:

Milestone	Date
Project Kick-Off	Dec 2008
Development (Req'mt, Design, Coding, Testing)	Jan 2009 – Oct 2009
User Acceptance Test (Round 1)	Oct 2009 – Dec 2009
User Acceptance Test (Round 2)	Dec 2009 – Jan 2010
Parallel Run	Jan 2010 – Feb 2010
Go-Live	18 Feb 2010

Settlement Project Challenges

- Change management
- Technology / product management
- Project lifecycle management
- Stakeholder management

Conclusion

Key Lessons

- Clear and concise market rules
- Proof of concept for untested technology
- Leverage on proven experiences for reviews
- Not just about technology, but processes and people

Energy Market Company

Thank You

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