ECE4886 Smart Grids

MONASH UNIVERSITY · ELECTRICAL ENGINEERING · SEMESTER 2, 2026

EXAM REVISION SHEET
Side 1 of 2 · methods + rules
V2 · 2026-10-25

Full guide + ask Sia about ECE4886

SIDE 1/2 EXAM MAP · DEFINITIONS · METHODS · DECISION RULES · COMPARISONS

REVISION · VERIFY LMS INSTRUCTIONS

Semester 2, 2026

1 · Exam map

COURSE.JSON · BRIEF

Labs 30% | 10% | Final 60%

CURRENT COMPONENT	WEIGHT
Four simulation laboratory reports	30%
Mid-semester test	10%
Final assessment	**60%**

Permitted materials: not confirmed for this offering in the course materials we hold — check the exam instructions on the LMS.

PRIORITY *Recite definitions, then apply the decision rule to a changed condition, then state the evidence boundary.*

2 · Smart-grid boundary

W1

★ *Smart grid* = sensing, communication, automation and market coordination augmenting the physical power system. Start with sources, loads, lines, transformers and connection points; add measurements, then the actor and feasible action.

physical network → measure + communicate → actor + action

physics constrains every layer

W1 functional map: energy path → information → control authority.

DECISION SEQUENCE

```
boundary → electrical quantities → measurement class → responsible actor → executable action → review signal
```

OBSERVATION	WHAT IT PROVES	WHAT IT DOES NOT
Meter sees state	Visibility	Command path
Controller issues command	Control request	Capacity to execute
Installation record	Potential capacity	Current output

Connection point is the electrical boundary for power, voltage, protection and responsibility. ***AC phasor*** represents sinusoidal steady-state magnitude and angle under an agreed frequency reference.

LIMIT *Digital coordination never overrides Kirchhoff constraints, equipment ratings, protection settings, or estimated-versus-measured state.*

CHANGED CASE *Remove feeder telemetry but keep installation records: planning can still use standing capacity and location; present output, voltage and loading lose support. Before curtailment, name the actor, responsive device, obligation and connection-point sign convention.*

3 · Switching & conversion

W2

Switching state = a semiconductor conduction combination for part of a switching cycle. ***Topology*** fixes feasible connections; ***modulation*** selects states to approximate the desired average waveform or power exchange.

DC link — switch bridge — filter → AC grid

request remains limit-bound

W2 redrawn: DC source → bridge states → filter → AC connection.

TRACE EVERY ANSWER

```
topology → switching sequence → averaged waveform → filter response → device/thermal/protection limit
```

LAYER	ASK	FAILURE EVIDENCE
DC side	Supplies/absorbs energy?	DC-link range
Bridge	Which path conducts?	Device current/loss
Filter	Where does ripple go?	Harmonics/transient
Control	Which pattern is selected?	Request clipped

TRAP *A clean averaged waveform can hide stress, harmonics, transient energy imbalance and infeasible operating regions.*

4 · Converter control

W3

GRID-FOLLOW	GRID-FORM
external V, angle	establish V, f
regulate I or P	within limits

current + energy limits

W3 comparison: reference behaviour differs; physical limits remain.

IF VOLTAGE FALLS	REASONING
Support loop requests reactive current	State the priority rule
Magnitude limit binds	Active/reactive services cannot both be assumed
Short response feasible	Sustained energy may still fail

CURRENT-LIMIT TEST

```
requested services → priority → saturation response → DC/thermal duration → protection consequence
```

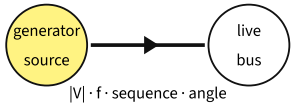
NEVER INFER *A control label alone does not establish implemented controls, disturbance behaviour, protection coordination or available energy.*

WORKED STEP *For each switching state, trace the conducting semiconductor path and DC-link energy. Only then infer the average fundamental; modulation alone hides device stress and harmonics.*

5 · Synchronous coupling

W4

Synchronous machine: steady rotor speed is locked to electrical frequency through pole structure. ***Excitation*** changes rotor field, internal voltage and reactive behaviour.



|V| · f · sequence · angle

W4 redrawn: all four synchronising conditions precede coupling.

CHANGE AFTER SYNCHRONISING	PRIMARY EFFECT
Governor/mechanical input	Mechanical power and rotor angle
Excitation	Field strength and reactive behaviour
Weak reference	Review fixed-grid assumption

BEFORE CLOSING

```
match voltage magnitude + frequency + phase sequence + phase-angle difference
```

TRAP *Matched voltage with reversed phase sequence is unsafe. Excitation cannot supply a missing synchronising condition.*

6 · Generation & wind

W5

wind → aero + shaft → generator interface → network

resource → deliverable grid service

W5 conversion chain: resource quality is not network deliverability.

QUANTITY	DO NOT SUBSTITUTE IT FOR
MW nameplate	Chronological output or secure output
MWh annual energy	Instantaneous dispatch capability
Availability	Market dispatch or deliverability
Capacity factor	Instantaneous secure capability

Compare conversion chain, controllability, variability, interface and system-service capability. For an equal-nameplate thermal-to-wind change, check time-aligned profiles, uncertainty, location, ramp certainty, fault response, inertia and services removed.

CHANGED CASE *Put wind behind congestion: resource availability is unchanged, but deliverability falls.*

7 · Solar, storage, flexibility

W6

State of charge is stored energy relative to usable range. ***Power rating*** limits how fast; ***energy capacity*** limits how long.

state of charge | power how fast | energy how long

preserve reserve + priority

W6 redrawn: state, rate and duration are separate constraints.

SCHEDULE INPUT	CHECK
Charge period	Solar export / connection constraint
Efficiency	Losses remain
Reserve state	Energy left for critical ramp
Discharge duration	Usable energy, not rating alone
Forecast update	Fallback and priority when wrong

FEASIBILITY ORDER

```
state of charge → power rating → usable energy/duration → efficiency → connection constraint → priority
```

LIMIT *Storage shifts and shapes energy; it does not create net energy, remove losses or guarantee value across conflicting objectives.*

8 · Dispatch under constraints

W7

$5/MWh 1 MW | $6/MWh 1 MW | boundary ≤ 1.5 MW

deliver 1 + 0.5 = 1.5 MW

W7 numeric guide case: the boundary clips the second offer.

GUIDE RESULT

```
two 1 MW resources; offers $5/MWh and $6/MWh
deliverable ≤ 1.5 MW → 1 MW + 0.5 MW = 1.5 MW
remaining 0.5 MW is not simultaneously deliverable
```

MARKET ITEM	ENGINEERING CHECK
Bid stack	Demand + network/ramp/minimum-output limits
Dispatch	Feasible resource instruction for interval/model
Price	Does not certify voltage, protection or security
Aggregation	Metering, responsibility, settlement, boundary

RULE *Apply physical constraints before selecting from the bid stack.*

9 · DER visibility ladder

W8

Standing data record relatively stable capacity, technology, location and capability. ***Real-time visibility*** is operational measurement at adequate resolution, aggregation and latency for the decision.

planning → forecasting → security

register | history + weather | forecast estimate | operating measure

W8 data ladder: registration, estimate and measurement serve different decisions.

FOR EACH LAYER RECORD	FAILURE QUESTION
Supplier + governance	Who owns/corrects it?
Update interval + latency	Fresh enough?
Location + aggregation	Can it see the constrained feeder?
Accuracy + resilience	Fallback if communications fail?

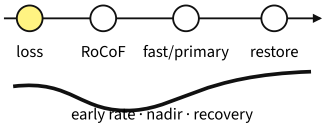
DECISION TEST

```
dataset resolution + latency + location + governance + resilience must suit the stated use
```

TRAP *More granular is not automatically better; statewide aggregation may improve forecasts while leaving feeder congestion and voltage blind.*

10 · Frequency dynamics

W9



early rate · nadir · recovery

W9 redrawn: separate early rate, response, nadir and recovery.

STAGE	CONTROLLING EVIDENCE
Initial movement	Imbalance, rotating energy
Fast injection/load reduction	Trigger, delay, current limit, headroom
Primary control	Available response
Restoration	Energy duration and recovery

Frequency indicates active-power balance; ***inertia*** is stored rotating energy resisting rapid change; ***RoCoF*** is the early speed of frequency movement.

LIMIT *One metric cannot establish security: location, network strength, protection, delay, recovery and contingency size also matter.*

11 · Power-flow method

W10

A ***bus*** is a model node where voltage is represented and connected injections, loads and branches balance. A ***power-flow solution*** is a steady-state calculation; the ***slack reference*** sets angle and balances residual active/reactive mismatch.

topology + base → bus types + signs → solve balance → inspect limits

V · loading · Q limits · slack

new topology/injection → new case

W10 redrawn: model first; convergence precedes constraint inspection.

BEFORE SOLVE	AFTER SOLVE
Topology, base, units	Voltage magnitudes
Bus types, load signs	Branch loadings
Generator/transformer limits	Reactive limits
Ratings + reference	Slack balancing duty

CONSTRAINT RESPONSE SET

```
redispatch · reactive support · transformer control · curtailment · reinforcement
```

TRAP *Convergence is not validity. Non-convergence is not automatically insecurity: check data, units, initialisation and model validity.*

12 · Fault & protection

W11

fault type + topology → Thevenin at fault → duty level → clear select

magnitude + time + selectivity

prospective ≠ interrupted current

W11 redrawn: define scenario before reducing the network.

STATE EXPLICITLY	WHY IT BITES
Purpose	Rating, relay, coordination or strength
Fault + pre-fault state	Defines study
Grounding + topology	Changes equivalent
Machine/inverter model	Contribution may be controlled/time-dependent
Max/min condition	Duty versus detection

PROTECTION DECISION

```
defined scenario → equivalent seen at fault → prospective duty → device rating → clearing time + selectivity
```

LIMIT *A symmetrical RMS result does not cover asymmetric peak, DC offset, arc impedance, grounding, relay dynamics, inverter controls or every topology.*

AskSia
FORWARD THIS TO YOUR TUTORIAL GROUP

Check your exam instructions on the LMS for what you may bring; use this sheet to revise and self-test.
Monash Semester 2 final assessment period, 2–18 November 2026 (check your personal exam timetable).

ECE4886 Smart Grids · self-test drills

MONASH UNIVERSITY · CHANGED CASES · JUDGEMENT CARDS · CLASSIC TRAPS

EXAM REVISION SHEET
Side 2 of 2 · drills + checks
V2 · 2026-10-25

Full guide + ask Sia about ECE4886

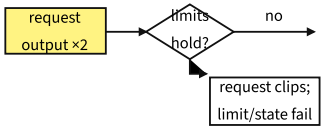
SIDE 2/2 FIVE CHANGED CASES · METHOD CHOOSER · IF X → DO Y · TRAPS · EXAM-MORNING PLAN

ANSWER BEFORE REVEALING PATH

ECE4886 · Semester 2, 2026

D1 · Inverter request ×2 W2 WORKED

Prompt. An inverter injects from a DC source through bridge and filter. Double requested output while DC-link voltage, switching frequency and thermal capacity stay fixed. Can modulation alone deliver it?



check I · loss · DC · thermal

Answer path: requested waveform never erases the device constraints.

1. Draw DC link → bridge → filter → grid.
2. Name switching states producing positive/negative terminal voltage.
3. Explain modulation changes the average fundamental component.
4. Audit device current, switching loss, DC-link range, thermal limit and protection.
5. Identify the first assumption that fails; state the clipped result.

ANSWER

```
No automatic doubling. Modulation is
the request mechanism; fixed
physical limits decide feasible
output.
```

FULL-CREDIT EVIDENCE	CLASSIC MISS
Conducting path + energy balance	Only draws average waveform
Names the clipping limit	Assumes ideal topology sustains it
Filter carries ripple	Filter "creates" energy

J1 · Converter judgement W2-3

IF YOU SEE… → DO…

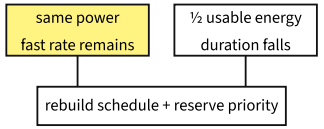
```
control label → ask for implemented
reference + feedback
multiple services → state priority
at current limit
short response → separately check
stored-energy duration
average waveform → reopen device
stress + harmonics
```

SELF-TEST *Can your last sentence name the observation that would reverse the decision?*

REPAIR *Start with DC source → bridge → filter → grid. For each state, name the conducting path and DC-link energy; then test device current, switching loss, DC-link range, thermal limit and protection. Modulation output alone cannot prove feasibility.*

D2 · Half the usable energy W6 WORKED

Prompt. A battery supports the steep evening net-demand ramp after midday rooftop PV. Halve usable energy while retaining the same inverter power. What remains feasible, and what fails?



W6 changed case: power capability can remain while duration fails.

1. Keep connection-point constraint and forecast case fixed.
2. Separate state of charge, inverter power and usable energy.
3. Fast, short services may remain within the same power rating.
4. The promised discharge interval must be shortened or rescheduled.
5. Preserve reserve for the critical ramp; state what yields first.

ANSWER

```
same maximum rate; reduced response
duration. Re-test schedule,
efficiency, reserve state and
connection constraint.
```

CASE CONDITION	CORRECT JUDGEMENT
Charge at solar peak	May absorb local export
Discharge too early	May empty before critical ramp
Forecast wrong	Use update/fallback + stated priority
Energy rich, power limited	Cannot increase rate
Power capable, energy poor	Cannot sustain duration

J2 · Storage judgement W6

IF YOU SEE… → DO…

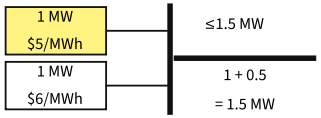
```
MW claim → ask "how fast?"
MWh claim → ask "how long?"
flexibility interval → apply SOC +
efficiency + reserve
conflicting services → write the
priority rule
```

TRAP *Storage does not create net energy or remove conversion loss.*

DURATION CHECK *Apply state-of-charge and efficiency before usable duration. A fixed schedule can absorb solar export yet discharge too early; compare forecast-updated control and state the priority if forecasts fail.*

D3 · Dispatch through 1.5 MW W7 WORKED

Prompt. Two distributed resources each offer **1 MW**, at **$5/MWh** and **$6/MWh**, behind a **1.5 MW** network constraint. Construct a feasible aggregation.



0.5 MW remains non-deliverable

W7 worked result: economics is filtered through transfer capability.

CALCULATION

```
requested aggregate = 1 MW + 1 MW
constraint = 1.5 MW
take lower offer: 1 MW
remaining deliverable: 0.5 MW
feasible total = 1 + 0.5 = 1.5 MW
```

Changed condition. Raise the connection constraint to **2 MW**, bids unchanged. Both offers become deliverable; offer prices, metering needs, dispatch responsibility and settlement boundary do not thereby change.

STEP	WHAT EARNS THE MARK
1 · Order	$5 before $6
2 · Constrain	Apply 1.5 MW boundary
3 · Allocate	1 MW + 0.5 MW
4 · Interpret	0.5 MW unavailable simultaneously
5 · Bound	Price ≠ local voltage/security proof

J3 · Market judgement W7

IF YOU SEE… → DO…

```
bid stack → apply network, ramp,
minimum-output limits
low price → do not infer technical
feasibility
aggregation → locate boundary,
meter, actor, settlement
constraint change → say what changes
and what does not
```

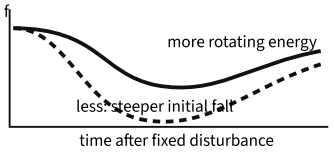
Exam-morning plan STUDY STRATEGY

PASS	ACTION
1 · Retrieve	Say each three-term chain without notes
2 · Draw	Connection point; sign convention; actor
3 · Contrast	Power/energy; visibility/control; price/physics; steady/dynamic
4 · Drill	Do one changed case; predict before answer
5 · Audit	Units, topology, limits, evidence boundary

FINAL MINUTE *Replace every absolute claim with the condition that makes it true. Check what the LMS says before the assessment.*

D4 · Less rotating energy W9 WORKED

Prompt. Hold generation-loss size fixed but reduce available rotating energy. Predict the initial frequency change; keep later reserve quantities separate.



W9 qualitative prediction: less rotating energy → faster early decline.

1. Name the active-power imbalance and fixed contingency.
2. Reduced rotating energy means less initial resistance to frequency change.
3. Predict a larger-magnitude early RoCoF / more rapid decline.
4. Do not automatically change later reserve quantity; inspect delay, headroom, current limit and stored-energy duration.
5. Trace nadir, recovery and recovery-energy requirement separately.

ANSWER

```
same disturbance + less rotating
energy → steeper early frequency
movement; later security still
depends on response timing, headroom,
energy and location.
```

NAMED FEATURE	EVIDENCE REQUIRED
"Synthetic inertia"	Trigger, power source, current limit, recovery
Fast response	Latency and headroom
Secure recovery	Duration + energy restoration
One RoCoF value	Not the whole security outcome

Power-flow result ledger W10 METHOD

Record topology, changed input, affected buses and branches, active constraint, slack response and any control limit. Predict qualitative redistribution before solving; use it as a plausibility check.

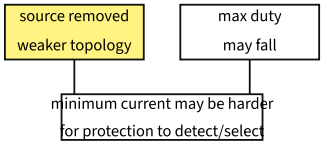
METHOD PATH

```
topology + injections → bus/reference
model → solve → inspect constraints →
compare feasible responses
```

SOLVER/RESULT	NEXT CHECK
Converged	Voltage, branch, reactive and slack limits
Limit exceeded	Redispatch/Q support/tap/curtailment/reinforcement
Non-convergent	Topology, units, data, initialisation, model validity

D5 · One source removed W11 WORKED

Prompt. For a three-phase distribution-bus fault, remove one upstream source. Explain why maximum duty may fall while minimum-fault detection becomes harder.



W11 changed case: lower duty can worsen sensitivity/coordination.

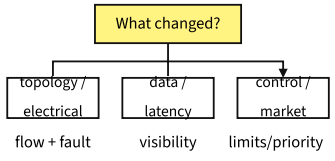
1. State purpose, fault type, pre-fault state, grounding and topology.
2. Build the positive-sequence network under the defined assumptions.
3. Reduce to the equivalent seen from the stated fault location.
4. Compare prospective duty with switchgear assumptions.
5. Add clearing time and selectivity; compare maximum and minimum conditions.

ANSWER

```
weaker source condition can reduce
prospective maximum current, yet low
fault current may challenge relay
pickup and selective clearing.
```

DO COMPARE	DO NOT COLLAPSE
Maximum vs minimum topology	Duty vs detection
Fault types	Three-phase vs every fault
Machine vs inverter model	Sustained source vs controlled contribution
Prospective current	Current actually interrupted
Magnitude + time	Fault level alone

Method chooser W1-11



Chooser: identify the changed layer before selecting the method.

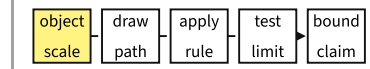
Classic traps A W1-6

IF THE SCRIPT SAYS…	REPAIR IT WITH…
"Smart" therefore feasible	Physical boundary, rating, protection, evidence status

Classic traps B W5-11

IF THE SCRIPT SAYS…	REPAIR IT WITH…
Capacity factor = dispatch	Keep annual energy and instantaneous output apart
Battery MW gives duration	State of charge, usable energy, efficiency, reserve
Price certifies feasibility	Network, voltage, ramp, protection constraints
Installed DER = current output	Forecast/measurement resolution and latency
One frequency metric = secure	Location, delay, headroom, duration, recovery
Converged = valid/secure	Inspect voltage, thermal, Q and slack limits
Symmetrical RMS = interrupting duty	Fault type, asymmetry, clearing time, device action

Universal answer scaffold GUIDE STRATEGY



fact → mechanism → constraint
counter-evidence → conditional
actor · unit · sign · time

Five moves: fix the object, trace mechanism, then bound the conclusion.

1. **Object:** define term at the task's unit, actor, scale and operating state.
2. **Path:** draw electrical energy path before adding measurement/control/price.
3. **Method:** name inputs, assumptions, steps and output.
4. **Changed case:** predict direction before solving; change one condition.
5. **Boundary:** state evidence that narrows or reverses the answer.

QUALITY CHECK *Does each comparison use the same boundary? Can the stated diagnostic genuinely change the conclusion?*

Fast recall chains W1-11

```
network → measure → actor → action
topology → switch → average → filter
→ limit
resource → interface → deliverability
→ service
imbalance → RoCoF → response → nadir
→ recovery
model → solve → inspect → changed
case
fault scenario → equivalent → duty →
clear selectively
```


AskSia
FORWARD THIS TO YOUR TUTORIAL GROUP

Check your exam instructions on the LMS for what you may bring; use this sheet to revise and self-test.
Monash Semester 2 final assessment period, 2–18 November 2026 (check your personal exam timetable).